SCIENCE NEWS

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CONTENTS

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Editorial

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Ideas we must have, and without them facts are nonsense But ideas, like practical methods, are best out in the open, where everyone can see them for what they are, with their little invalid assumptions and shoddinesses It is our faith and our policy to emphasize the thought over the fact in the fields of science our articles review and we shall do this more and more in later issues In this way we hope not merely to provide a mental map on which the factual details can later be inscribed but further to stimulate the progress of Science itself by drawing attention to ideas of one speciality which may find a use in another, unrelated to it, for often a single new intellectual approach proves fruitful over a wide area

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The Prehistoric Society

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This issue opens with an account of how the archaeologist gets to work, and closes appropriately with a study of that

subject which has made our culture materially so different from the preceding Stone Ages—Metals and Alloys. Dr Fox, in an article which repays careful study, discusses the underlying principles in the production of alloys, and the problems of modern metallurgical research. His essay can be profitably read with the article on Metals by Sir Lawrence Bragg which appeared in our first issue In *What the Earth is Made of*, Lieut.-Colonel Tillotson excavates a good deal deeper than the ten feet or so of surface soil which interests the prehistorian, and describes how earthquakes and artificial explosions are used to probe the composition of the underlying strata and to search for oil Mr Haslett discusses the origins of Coral Islands, and the light thrown on this problem by recent excavation, in his Research Report *Viscosity*, by Dr Bell, is an elementary introduction to the modern conception of the liquid state, which is exemplified also in a note on *Glass*. *Group Psychotherapy* explains the general approach in the psychological treatment of neurosis *Demography, Science and Administration* is a critical discussion of the study of population and its vast importance for modern government, which can only apply controls successfully to a society whose size and composition are known. Throughout, our contributors are striving to give a critical, balanced account, to reveal how the new 'facts' were obtained and what their significance is taken to be. We want to offer something more valuable than knowledge, and that is Understanding

Scientific Prehistory

L W CORNWALL

What is Prehistory?

WRITTEN records of the past are the raw material of History – but what of the long career of mankind before writing was invented? That is the field of the science of Prehistory In the Near East writings are found from as early as about 4000 years B C but in Britain Julius Cæsar s account of the first Roman invasion brings *our* prehistoric period to an end as late as 55 B C

The prehistorian compiles his account from the traces left of their lives and activities by peoples without writing His principal helper is Archæology the science which studies human culture through its material equipment but, especially for the earlier part of man's story many other sciences have an important contribution to make

In this sense palæontology and geology are the handmaids of Prehistory They enable us to discover something of the biological origins of the human race and of the nature of the world in which the earliest men lived their way of life and relation to their environment Another contributor is comparative anatomy which concerns itself with their rare skeletal remains and gives us some account of their forms and faces Archæology takes a hand when their practically indestructible stone implements are in evidence and becomes the principal instrument in exploring the later periods when with advancing material culture remains of the homes villages cemeteries tools weapons ornaments and so on of ancient man become available for examination

Many of the rarest and most instructive relics of man s remote past such as skulls, bones and stone implements have been discovered by chance when digging foundations

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pre Roman Early Iron Age. If the place was merely abandoned and left to rot, hardly anything of use to the inhabitants would be left behind, but we should still be able to glean something from the rubbish. If, on the other hand, it was suddenly destroyed, as by fire, a great many objects [illegible]

[illegible]

or a stockade We should find the bank and ditch, or the post holes, identify the gateway, the stock-corral, the granary and the store-pits These last would contain a certain amount of [illegible]
of tools, [illegible]
and farmy[illegible]



[illegible]

(Bersu Excavations at Little Woodbury Wilts. Proceedings of the Prehistoric Society 1940)

with a thatched roof, of which only the post holes or charred stumps of the timbers would remain There may

for buildings, levelling roads or working gravel Many others must have passed, unnoticed and unrecorded by science, into concrete-mixers and brick-kilns. Some few have been saved from a similar fate by the devoted vigilance of enthusiasts and the co-operation of managers, foremen and labourers

Most prehistoric material, however, has been obtained by systematic excavation, in places where some chance discovery has shown the presence of ancient remains or where actual evidence of man's occupation or activities can still be discerned at the surface

Having assembled his finds, the prehistorian cleans, repairs, reconstructs and studies them trying to extort, from the objects themselves and the circumstances in which they were found, every piece of information which they can yield as to their nature, use, method of manufacture, how they came to be where they were found, what sort of men made or owned them By comparison with similar specimens already known quite a detailed picture of the persons, the world and the lives of an ancient people can be compiled

The work is not finished until it is published, so that not only conclusions, but the evidence itself and the argument leading to the conclusions, are available to anybody interested In digging up a site the excavator has destroyed the text of an ancient document The finds are only illustrations to it Nobody can ever again read what it contained unless he reconstructs the site in a publication, describing every detail observed in the field, whether he has understood its meaning or not As knowledge advances, in the future, it may easily be found that his conclusions were quite mistaken, but, if the facts are all there, better informed prehistorians may be able to give a more accurate interpretation

What the prehistorian finds – and what he doesn't

Let us imagine a relatively advanced prehistoric homestead, such as Little Woodbury (Plate 9), of the immediately

occasionally, in limestone quarries which expose the filling of ancient caves The bones of extinct and still surviving species of animals among which they lived are found in the same places This stage was the Old Stone Age or Palæolithic period In the later part of it the climate of what is now temperate Europe became almost arctic at times Mankind took to caves in limestone rocks and over hanging shelters (Plate 8), and it is in, and in front of, these places that their tools, animal bones, wall paintings and, sometimes, their own remains are found

Later, forests covered most of the land Middle Stone Age, or Mesolithic, men lived in the more open places – sea- and lake beaches in fens and bogs and on sandy wastes Mounds of shells and rubbish, the waste from their beachcombing and hunting, yield evidence of their way of life as well as their tools and sometimes their skeletons

Soon we find the first settled communities tilling the soil, stock rearing and (most important for us) using pottery Their settlements are found on the open Chalk downs and hill tops, associated with the long barrows, cairns and chambers of huge stones which they built as communal tombs (Plate 2)

Round barrows and other circular monuments, such as Stonehenge belong to the Bronze Age, though it is likely that some of them, at least, continued to be used and venerated up to historic times. There are also cemeteries of cremated burials in pottery urns of the later Bronze Age Only very few settlements of these people are known

this country

Many commanding hill tops are crowned with forts and earthworks dating from the Early Iron Age (Plate 3) We also know some habitation sites and widespread field-systems of the time The latter are often marked by

have been wattle hurdling daubed with clay for the walls If this had been burnt the impression of the hurdle might be left for us to find Of course there would be pottery, but many of the other household fittings and utensils must have been of wood All this, with basketry and woven textiles, would perish, but clay or stone spindle-whorls and loom-weights would survive to testify to the manufacture and use of textiles Nothing made of hide, horn, sinew or gut – all useful primitive materials – would remain, but bone and deer-antler implements might be preserved – blade-bone shovels and antler-picks, pins, weaving-combs, etc – and even, perhaps, much corroded iron tools – axes and bill-hooks The rest of the farm implements, mostly of wood, must have rotted Of clothing we would find only bone or metal fittings and ornaments – pierced animal-teeth, shells and beads for stringing, bronze brooches and so on Sling-stones, flint arrowheads and metal weapons may have survived, of food, only the meat-bones and perhaps carbonized grains of corn

In peat-bogs and other waterlogged deposits, objects of wood, basketry, textiles, leather, grains, fruits and seeds are occasionally preserved to give us a glimpse of how much is generally lost (Plate 13)

For still earlier times, when men lived in caves or in the open and had a much scantier equipment than this, there is even less to show – flint and other stone implements, bone tools, meat-bones and, perhaps, a few pierced teeth, shells and other ornaments Even pottery, the standby of the later periods, is lacking, but the caves have yielded clay-modelled animal figures and pictures, chiefly of animals, engraved, carved and painted on the walls

What is a 'dig' and how is it done?

(a) Where to dig.

The flint hand-axes and flakes of the earliest men, and their very rare bones, are generally found by chance in commercial excavations — gravel-, sand- and clay-pits, and,

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single vessel every one is kept, in the hope that the pot may be rebuilt or at least its shape recovered.

Photography at every stage saves pages of description in the eventual publication More important it is *prima facie* evidence of the original appearance of structures and objects which may have had to be moved or destroyed as the dig proceeded Archæological photography is a special art, beset with snags and limitations It is well to be sure that a good negative has been obtained before the irreplaceable subject is demolished

Samples of shells, bones soils from the different layers, peat charcoal rocks and minerals (in the case of geological deposits), food grains and industrial waste (e g metal slag) may help after examination, to fill in the picture given by the other finds They are best taken in person by the expert who will examine them

Deciphering the story told by the finds

(1) *The study of types*

Ancient man was bound by tradition and successive generations tended to reproduce the types of implements, pottery and so on used by their forbears Changes both of evolution and degeneration, took place by degrees insensible in any one lifetime The archæologist therefore, bases many of his conclusions on similarities, and the indicated relationships between known types and the particular objects he is studying A whole assemblage of characters common to the culture at his site and sites known elsewhere is even more convincing evidence of relationship Thus a particular group of people buried their dead in a crouched attitude in round barrows, used winged and tanged arrowheads of flint and placed with each body a clay beaker of characteristic form with a peculiar style of comb-impressed decoration (Plate 12) This assemblage, when found at two widely separated places establishes a close relationship We do in fact, recognize the Beaker Folk of the early Bronze Age by this

These principles apply to every dig and every archaeological period, with variations in plan of action for particular cases. A round barrow, or other circular structure, may be excavated a quadrant at a time (Plate 7), an area such as a cave-floor or an ancient land surface, without visible structures, by arbitrary squares, the line of a wall or ditch plotted by short transverse trenches at definite intervals.

Interesting details, such as burials and groups of pottery or post holes denoting wooden buildings, hearths and so on, are carefully cleaned and recorded in place, with every associated object, before anything is moved.

Finally, the dig is filled in and levelled off.

How the fieldwork is recorded and what the excavator takes home

Of no less importance than the actual digging is the recording in the field. The field notebook contains a day to day account, with detailed small scale-plans and sections, of the work as it is actually done. Trenches or areas, and each distinct level in them, receive identifying symbols. Finds in them are individually or collectively marked with their appropriate locations and a reference to the page of the notebook on which their discovery is recorded. Objects other than pottery may be entered on cards with serial numbers, each with a rough drawing, measurements and description and all the relevant information as to its original situation and position.

Pottery, which may be very plentiful on later sites, is washed, sorted and selected on the site. Much of it may consist of small undistinguished sherds belonging to a common and well known type. Once enough types have been selected, establishing every characteristic variety of [illegible]

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they were also numerous in western Europe when the men of the early Old Stone Age were living, though the climate

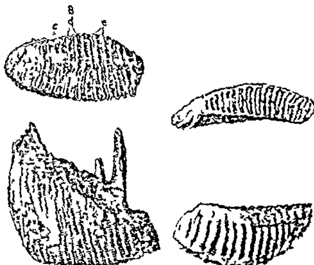


Fig. 6 [illegible]

From Zittel s Textbook of Palæontology Macmillan

was not very different from that of [illegible]

[illegible] of southern France, belonging to later stages of the same cultural period

Nor are bones the only indicators of climate Sea and freshwater shells and land snails can indicate fluctuations far less extreme than these A few degrees of change in average annual temperature or sea salinity a few inches difference in rainfall, will be reflected by alterations perceptible to the conchologist in the relative numbers of the



Fig 3.—A typical Early Iron Age household pot from Maiden Castle, Dorset and a bronze 'situla' or bucket from N Italy, of which the former is a debased form, translated from metal into clay
(A. from Wheeler Maiden Castle Soc of Antiquaries, London, 1940 B from Déchelette Manuel d'Archéologie préhistorique, A. & J. Picard, Paris, 1908)

Germany, at some of which implements and actual remains of Palæolithic man had been discovered. He found that *his sites fell into two well-defined groups, in one of which* a third to a quarter of the remains of elephants belonged to young beasts less than 6 years old. In the other group older animals predominated, some two-thirds being over *50 years old and none under 6. Now the first group in*cluded all the sites at which man was known to have been living, as well as two, showing a small proportion of young animals, where there was no evidence, at that time, of his presence. *Soergel concluded that, in those places, man had* hunted the inexperienced members of the herds, for nothing would otherwise account for the difference in age-distribution. Further support for this theory came some years later, when a human skull was found at Steinheim, one of his two anomalous sites. The other remains a blank, but we look forward hopefully to hearing, one day, that the presence of man has been proved there also

To-day we associate elephants, rhinoceroses and lions with tropical regions. The deposits just described show that

they were also numerous in western Europe when the men of the early Old Stone Age were living, though the climate

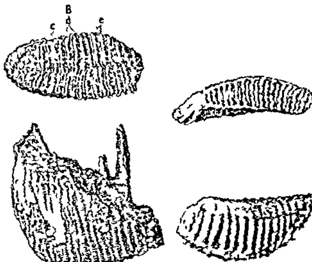


Fig. 4.—Elephant teeth. On the left, two views of an upper molar of the Mammoth (*Elephas primigenius*), whose presence in a geological deposit denotes a cold climate for its formation. On the right corresponding views of a lower molar of *Elephas antiquus*, which lived in a temperate or warm climate

From Zittel's Textbook of Palaeontology, Macmillan

was not very different from that of [illegible]
other [illegible]
of rem[illegible]
of so[illegible]
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species composing the molluscan faunas of beaches, river flood-loams and field-ditches

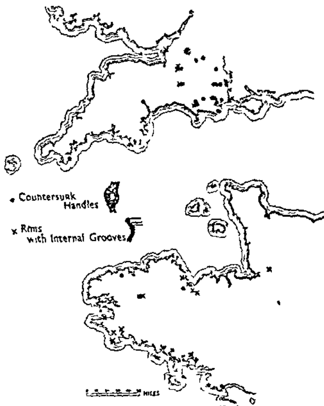
The botanist is another specialist whose help is often required by the prehistorian He can determine the species of trees and bushes from sizeable fragments of charcoal in the hearths of prehistoric sites Quite a full picture can be made in this way of the local vegetation of the time In a peat or a lake-silt the very wood of piles or wattle-work may be preserved for him to determine Even wind borne pollen of trees and plants, preserved in such conditions, can be identified under the microscope Pollen-analysis of a level in a peat showing the presence only of pine and birch woods suggests a climate colder, at least in winter, than one with oak, elm, lime and other deciduous forest trees This method is now being extended to include the pollen of herbs and grasses as well as of trees.

The botanist may also be able to trace, from a few carbonized grains or a grain-impression in the once-plastic clay of a pot, something of the story of prehistoric cultivated wheats and the travels of the men who sowed and reaped them

The composite picture of animals and plants contemporary with early man may be of importance in dating, at least for the earlier periods of prehistory

Apart from the palæontologist and the botanist, the help of the expert on soils is often needed In later times, climate and surroundings were not very different from what they are to-day, but the soil-scientist can recognize a 'fossil' turf-surface in the section of an Iron-Age rampart which has been reconstructed in antiquity (Plate 4) as readily as he does the weathering in a boulder clay or loess due to some thousands of years of exposure

The petrologist may be able to say where the characteristic stone for a particular 'polished' Neolithic axe originated That of an axe found in Hampshire must have been quarried at a particular place in Cornwall. Axes of a rock from the Lake District have been found near Barrow-in-


• Countersunk Handles
× Rims with Internal Grooves
MILES

and exchange, even in Neolithic times, is most striking

Similarly, the chemist may determine, from the composition of a far-travelled amber bead, whether it originated in East Prussia or Sicily A mineralogist may be able to decide, from traces of characteristic impurities present, the particular ore deposit from which the metal of a Bronze-Age spear was smelted The student of animal bones can help to unravel the history of domestication in animals Working with the human remains, the anatomist and physical anthropologist seek to define the racial affinities of the people concerned

Experts' reports on materials from any one excavation are not always impressive or abounding with spectacular results Now and again, one of them may, however, be able to say that, to the best of his knowledge, a particular object or material from a British site could only have come from (say) the Rhineland At once a connection of some kind is set up between two remote prehistoric peoples, of which the importance to the prehistorian may prove to be very great It is worth many inconclusive investigations to obtain even one such informative result

How long ago was it?

Archæological deposits consist mainly of the rubbish of human occupation and have slowly accumulated where they lie, often in more or less distinct layers *Provided that there has been no later disturbance*, it follows that what is found deep down must be earlier than what lies above it Very often, however, there *has* been some disturbance – as when later occupants dug pits or wall foundations into earlier rubbish, or when rabbits and badgers have been active If we find, say, a Roman coin in the same layer as Neolithic pottery, there is only one possible conclusion that the deposit has been disturbed and mixed, perhaps as early as Roman times, possibly only quite recently Certainly the pottery is not in its original context The latest datable object dates the layer in which it is found If however, we

find the same New Stone Age pottery in a layer including nothing demonstrably later in date we may be reasonably certain that we are in a stratum which has lain undisturbed since the time when that sort of pottery was being made and used The same stratigraphic principle (derived of course from geology) applies to Old Stone Age relics in geological not humanly formed deposits This principle gives us a *relative chronology* the bare order in which prehistoric events occurred

Within the last ten years or so geology has developed tentative *absolute time scales* dating in years

One of them is based on the known extremely slow rates of decomposition of traces of radioactive substances present in rocks and minerals This dates the earlier geological periods

Prehistory is of course only seriously concerned with the Pleistocene and Recent periods of the geologists comprising perhaps the last million years of the Earth s estimated age of 3 000 million The sub-human ancestors of man must have been in existence before this but the first undoubted men known to us belong to the early part of the Pleistocene say 600 000 years ago

Working on geological evidence in the Alpine region Penck and Bruckner constructed a curve to show the growth and retreat of four main Pleistocene glaciations and to indicate their probable duration and extent

Now astronomers for their own purposes have calculated for the last million years the effect on the amount of solar radiation received at the Earth s surface of cyclic changes in the complicated motions of our globe Some geologists interested in the Pleistocene Ice Ages have noted a degree of correspondence between these results and their own which seems to exceed [illegible]

on a basis of ma

connection theref

they have provisionally correlated the more detailed radiation curve and its time scale with the glaciation-curve

and exchange, even in Neolithic times, is most striking

Similarly the chemist may determine, from the composition of a far travelled amber bead, whether it originated in East Prussia or Sicily A mineralogist may be able to decide, from traces of characteristic impurities present, the particular ore-deposit from which the metal of a Bronze Age spear was smelted The student of animal bones can help to unravel the history of domestication in animals Working with the human remains the anatomist and physical anthropologist seek to define the racial affinities of the people concerned

Experts' reports on materials from any one excavation are not always impressive or abounding with spectacular results Now and again, one of them may, however, be able to say that, to the best of his knowledge, a particular object or material from a British site could only have come from (say) the Rhineland At once a connection of some kind is set up between two remote prehistoric peoples, of which the importance to the prehistorian may prove to be very great It is worth many inconclusive investigations to obtain even one such informative result

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(Fig. 6). The absolute durations and intensities of glaciation, and of the interglacial periods, indicated in this way, prove to be of much the same order as that suggested by Penck and Brückner on purely geological grounds. We thus obtain dates for the main events of the Pleistocene which, if not yet very accurate, are at least valuable working hypotheses and probably of the right order of magnitude.

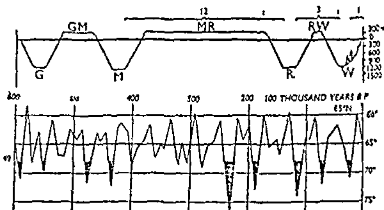


Fig 6—Glaciation- and radiation-curve The upper curve is that of Penck The axis represents the level of the present Alpine snowline with graduations above and below it in metres The dips in the curve correspond to the four Alpine glaciations, Günz, Mindel, Riss and [illegible] radiation received at Lat 65 N during the last 600 000 years The four groups of minima shown in full black are regarded by some geologists as corresponding with Penck's four glaciations. In this case, three of them are seen to have been double and the last triple Recent field work tends to corroborate this theoretical multiplicity of the glaciations

(Penck's curve re-drawn from W. B Wright: The Quaternary Ice Age, 2nd ed, Macmillan, 1936 Milankovitch's from Zeuner The Pleistocene Period, Ray Society, 1945)

During the last retreat of the ice sheets, certain banded or 'varved' clays laid down in glacial lakes have been shown to mark the seasons of retreat, by a thick layer formed during summer thaw followed by a thin band during the winter freeze up (Plate 5) Series of these have been counted and linked up and give reasonably reliable dates for the last 12,000 years. Now, with the varves can be correlated minor climatic phases botanically determined by pollen analysis The settlements and implements of pre historic man are also often accompanied by tree pollen, so that the dates of the varves can sometimes be transferred to the human cultures

Finally, we come to the astronomically fixed calendars and king lists of the earliest Near Eastern civilizations, which flourished long before western Europe emerged from savagery Datable objects traded and conveyed thence, when found with prehistoric European remains, afford approximate historic dates for these by synchronism, ample allowance having been made for possible long delay in transit.

A striking example of the method is made possible by the occurrence, in round barrows in Wessex, of segmented faience beads, clearly imported, of which the nearest known parallels were made in Egypt about 1400 B C From these we get an approximate absolute fixed point for our Early Bronze Age (Plates 14 and 15)

What do we get out of it?

A great contrast between History and Prehistory is that, while the former is largely concerned with the *doings of prominent individuals* Prehistory deals with the daily life of nameless ordinary people Dynasties and policies have passed unrecorded but we do begin to kno[illegible]

[illegible] equipment, economy society and ideas Unconsciously, perhaps, but

not less certainly, we compare what we can discern of the life of prehistoric man with our own. If we are tempted to feel a little patronizing towards the achievements of our ancient forbears, we should remember that we deserve no credit for having been born in this century and consider soberly how we, as individuals, might have fared in the conditions of, say, the Old Stone Age

Once started, knowledge and technology advance, to some extent, by their own momentum. Thus, the astronomer, the atomic physicist and the microscopist, among others, make prehistoric dating possible. Without their equipment and skill, it would still be a matter of pure speculation over most of the field of which we have knowledge.

Even to-day, when education is general and research is a field open to any trained inquirer, there are not very many original minds among our enormous populations. Is it not surprising, therefore, that the invention of so many of our basic economic activities is due to the ingenuity of prehistoric men – among them agriculture, domestication of animals, pottery, spinning, weaving, turning, metallurgy? No one will maintain that the technique of weaving was a chance discovery. Here are the working of brain and hand, the exercise of ingenuity and imagination, at their best. Though the smelting of copper ore was probably discovered by chance, how many of us, seeing a fragment of green malachite amid the glowing charcoal and finding a globule of copper among the next day's cold ashes, would connect [illegible]

heirs, in our time, it may well collapse.

Therefore, better to understand the hothouse civilisation we have built round ourselves, we need to understand the

origins of society – the Old Stone Age family feasting behind its blazing brushwood in the cave-mouth, the Neolithic farmer and his neighbours safe with their brim mine grain pits as the winter sets in, the barbaric Belgic conqueror and his followers lords of all the South and East of Britain before the Romans came

History is the connecting link between their times and our own but it is necessary to trace the devious career of man from his origins up to the opening of history, to obtain the fullest understanding of ourselves

tion of the eyeball must be made as soon as possible after death, in the first twelve hours. It is then kept in a cold room 24 hours or more, preserving it in the future recipient's blood with every desirable aseptic precaution. Unfortunately in some countries laws forbid any interference with a dead body until 24 hours after the death has been registered. This must be modified as soon as possible because of the obvious social importance of the operation.

The Americans, with that sense of size, organisation and publicity peculiar to them, have conceived of the creation of a special bureau to supply the necessary material: 'The Eye Bank for Light Restoration.' To this agency (in New York) come those who will have to have an eye removed, to offer themselves for a future corneal transplantation. Furthermore, a great publicity campaign has been undertaken to encourage people of every race and all ages to leave their eyes to the bureau in their wills. They will be examined, and tested to confirm the possibilities of future use. Recently, to the original collecting centre has been added a teaching centre which gives every ophthalmic surgeon the opportunity to educate himself in the technique of operation. In the course of its first year's functioning this body has responded to more than 3,000 requests. Without going to the full length of such an organisation, which makes us smile a little, we would find it worthwhile to collect together offers and requests for corneal transplantation.

Operative technique

The graft can be penetrating or non-penetrating, total or partial, according as it involves all the thickness of the cornea or not, and all its surface up to the limbus (periphery of the cornea) or only a limited segment of that surface. We cannot for the moment make a success of a total graft for the whole of an opaque cornea. Actually the most frequently practised operation is a transplantation partial as regards surface – limited to a central zone 4 to 5 mm diameter corresponding to the visual area of the cornea

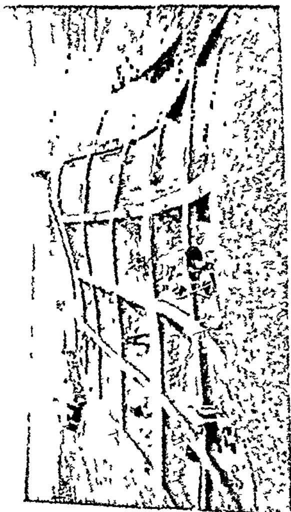




Plate 2 A dolmen a New Stone Age communal tomb probably originally covered with a mound of earth Pentre Ifan, Pembrokeshire (Grimes *Proceedings of the Prehistoric Society*, 1936)

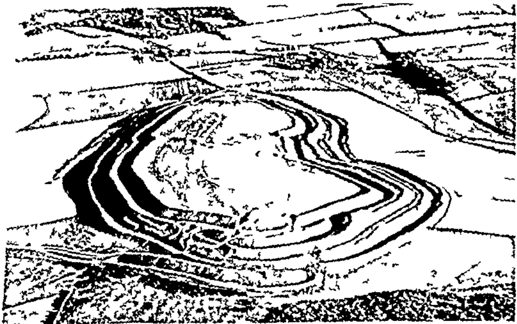


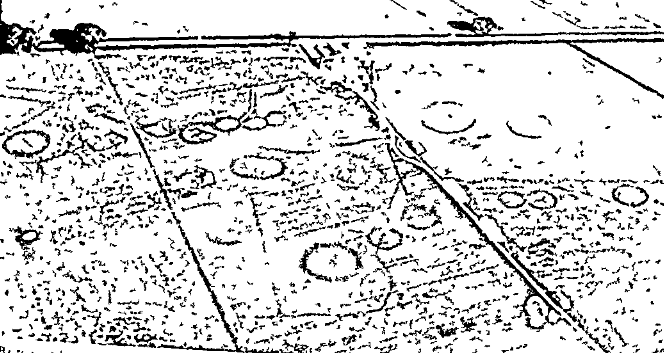
Plate 3 An Ea ly I on Age h ll fort Ma den Cas e Dorset fron tl e a r The la est reconstruct on of th defences was to res st the n as on of he Roman Empe or C audius n A D 45 (Wheeler *Ma len Castl D rset* Soc ety of Antiquaries London 1940)



Plate 4 Maiden Castle section of ditch near E. entrance (1) Turf line over natural silt (2) Artificial filling during a reconstruction of the defences (3) Hut floors of the Early Iron Age (4) Dump of the Roman period (5) Post hole (6) Early Iron Age metalled roadway
(Wheeler *Maiden Castle* Society of Antiquaries, London 1940)



Plate 4 Maiden Castle: section of ditch near E. entrance. (1) Turf-line filling during a reconstruction of the defences (3) *Hut-floors of the Ea[illegible]* Roman period (5) Post-hole (6) Early Iron Age metalled roadway (Wheeler: *Maiden Castle* Society of Antiquaries, London, 1940)



Barrow-circles and other traces of soil disturbance near Eynsham, Oxon, shown by crop-marks in an air photograph. (Grahame Clark, *Prehistoric England*, Batsford 1941) (*By permission of the Visitors of the Ashmolean Museum*)

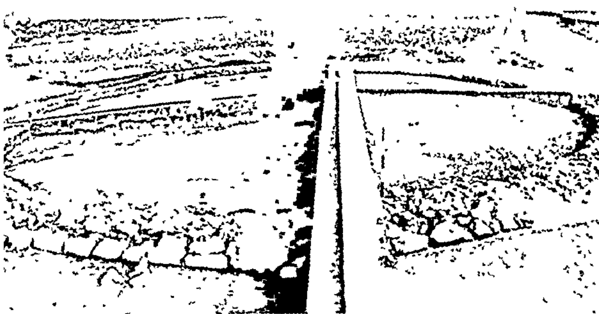


Plate 7 A Bronze Age round barrow excavated in quadrants (Excavated by W F Grimes Director London Museum) *Proceedings of the Prehistoric Society* 1939)



Plate 8 Rock shelter at Les Eyzies, Dordogne, France Later Old Stone Age man lived beneath the overhang Déchelette *Manuel d'Archéologie préhistorique* J A & J Picard, Paris, 1908)



Plate 9 Little Woodbury Wilts the site of the Iron Age farmstead and its surrounding ditch as revealed in an air photo (Grahame Clark *Prehistoric England* Batsford 1941) (By courtesy of the Controller of H M Stationery Office and Director General of the Ordnance Survey)

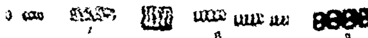


Plate 14 Faience and other segmented beads, mostly from Wiltshire (Beck & Stone *Archaeologia LXXXV* Society of Antiquaries London)

Plate 15 Segmented faience beads from Egypt mostly of the XVIIIth to the XXIIIrd Dynasties. (Beck & Stone *Archaeologia LXXXV* Society of Antiquaries London)





AUSTRALIAN SCIENTISTS' HOLIDAY EXPEDITION Plates 16–19
A party of Melbourne scientists collected many interesting botanical geological and ethnological specimens during a recent 5 000-mile holiday expedition from Port Lincoln in South Australia across the seldom-explored Nullarbor Plains to Perth (Western Australia). The party was led by Mr Russell Grimwade, president of the Melbourne National Museum trustees. Specimens collected will enrich the Museum and the Melbourne Herbarium (See page 128)



Plate 16 Sand dunes near Eucla at the head of the Great Australian Big where the only vegetation is clumps of nitre bush (*Photograph by Mr Rus Grimwade*)

Plate 17 Entrance to one of the Nullarbor Caves a geologists para which, owing to its remoteness and lack of water has been visited by c a handful of people (*Photograph by Mr Russell Grimwade*)

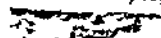


Plate 20 Photograph of horizontal strata at Filey Yorkshire showing layers of rock concentric with the centre of the earth like the layers of an onion Hence by extrapolation concentric layers deeper in the earth *Courtesy Leeds University* (See page 63 What the earth is made of)

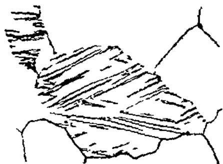


Plate 21 Pure magnesium as seen under the microscope at a magnification of 50 The parallel lines are indications of the presence of twinned crystals

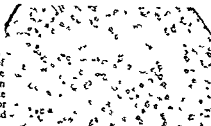


Plate 22. Magnesium containing 0 7 per cent of zirconium Note the change of grain size in comparison with Plate 21 (See page 135 Minor additions in metals and alloys)

... not previously found in
... ing of the white man to
... *by courtesy of the Mel-
bourne National Museum*)

and *total in thickness* – involving all layers of the cornea, whence the name of partial penetrating graft

Like the type of graft, the technique of implantation itself varies from author to author. We shall borrow the description of the Swiss masters, notably Franceschetti and Streiff who have a following in France. We must consider in turn

1 The preparation of the patient
2 Cutting the graft
3 Placing the graft on the diseased eye and keeping it in place
4 Post-operative care.

1 *Preparation of the patient*

A penetrating graft always requires the most minute preparation of the recipient's eye. As well as the cases where before the ... number of prepar... ologist alone can ... where grafting is ... important to insist on a whole series of preventive measures

From the first perfect asepsis of the whole region is essential. The instillation of penicillin drops will thus be very valuable. Anaesthesia will be obtained with cocaine drops and especially by the injection behind the eye of an anaesthetic solution of syncaine a compound allied to



Fig. 8.—While the eyelids are held open by the retractor local anaesthetic is injected into the eyeball. This is the left eye note the nose on the right of the diagram, and the eyebrow below

novocaine. Neighbouring parts (eyelids, skin) are likewise locally anaesthetised. Finally, two horizontal and two

CONTACT LENSES



Plate 23 Placing the plastic lens in position by means of a rubber holder The lens is placed upside down on the holder filled with fluid, raised to the eye as here and when in place the holder closed which releases the lens



Plate 24 The plastic lens in position Notice how it covers rather more of the eye-ball than the gap between the eye-lids

EYE GRAFTING

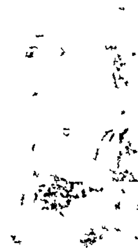


Plate 25 Right eye with corneal opacity before operation (see Eye-Grafting, page 30) Notice how the pupil is hardly visible



Plate 26 The same eye over a year after the operation in which new transparent cornea has been grafted in

pendicularly to the iris, so as to obtain a complete section, clean and clear, and to limit the movement of the trephine in depth in order not to wound the lens This is the most difficult point of the operation To simplify it, some practitioners make use of a little wooden or metal spatula, which they slide behind the cornea into the anterior chamber of the eye It then acts both as cutting board and protector

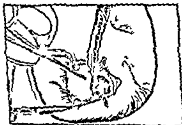


Fig 10—Cutting into the anterior chamber with a scalpel (right) to introduce the cutting plate (left)

The quality of the trepanning appears to be one of the essential elements in a successful outcome to the operation Once the opaque disc is raised, and the bed clear for the graft, it is brought up on its back on a little spatula slipped into the prepared bed and finds its right position with the help of pats from the spatula

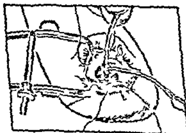


Fig. 11—The new transparent cornea is lowered into place Note the two sutures ready in position

Some surgeons then apply a very fine membrane to the whole extent of the cornea either eggshell lining or fine sausage skin the dimensions of which are approximately those of the cornea Then the threads are tightened (not

vertical threads are stitched across the eye so that they cross and form a tiny square At first they are left slack, but later when the graft has been put in place they are tightened and then form a little trellis to hold the graft in place As for the risk of a rapid rise in pressure of the intraocular fluids after the operation, it is avoided by drops which lower the tension of the eyeball (eserine, etc)

2 *Cutting the graft*

Whether one uses a graft from the dead or one from the living, it is detached for preference from the enucleated eyeball for this a trephine is used, a kind of tube with a very sharp end, the punch movement of which is limited to about 1 mm, which corresponds to the usual thickness of

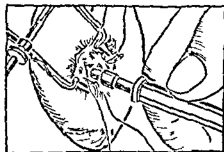


Fig 9—The punch removes a disc of opaque cornea

the cornea Its diameter varies between 3 and 6 mm according to the size of corneal disc it is desired to cut and which is to be taken from the centre of the cornea Great care must be used in pushing the trepanned disc very gently out of the tube It is placed on a little spatula, or better, on a flat circular drainer perforated with fine holes, and plunged into a glass dish filled with a physiological fluid or with serum from the future recipient of the graft

3 *Positioning*

A trephine with a slightly larger diameter is used on the diseased eye to remove an opaque disc from the centre of the cornea, taking great care to trepan absolutely per-

Unfortunately, problems other than those of optical correction obtrude themselves The fashioning and fitting of the lenses demands a high degree of skill and dexterity The delicate cornea may be injured by the wearing of an ill fitting lens, and there are cases in which even a perfect fit fails to bestow the desired degree of comfort. The average period of use at a stretch is still somewhere between five and eight hours

Perhaps the greatest limitation of the conventional form of lens is the gradual development of a cloudiness of vision similar in effect to that of a smoky atmosphere The clouding, which begins in most cases after 2½ to 4 hours use, is believed to be due mainly to the accumulation behind the lens of carbon dioxide, normally exhaled by the cornea into the atmosphere Recent experiments by Dr Josef Dallos, one of the pioneers of contact lens technique, have proved that clouding can be largely eliminated by the provision of ventilation holes in the scleral portion of the lens.

Several distinctive methods are employed in the fitting of contact lenses Many recognized authorities favour the moulded lens The technique consists of the making of an impression of the eyeball, from which a positive cast is prepared the lens being pressed from sheet plastic to conform to the curvature of the cast Other practitioners prefer a lens of conical form designed to fit a limited area of the surface of the eyeball A much favoured design in Great Britain is the ground spherical lens originally introduced by Zeiss All of these types which are made from so-called

[illegible]

Although glass lenses are not dangerous, the majority of [p]resent-day contact lenses are made from I C I plastic The advantages of contact lenses over spectacles include unrestricted field of vision security from displacement sporting activities such as swimming football and riding,

Contact Lenses

FRANK DICKINSON

CONTACT lenses have been in the news again recently They were worn by a well known professional footballer who paid high tribute to their efficiency

Spectacles always a handicap in most forms of sport are being replaced increasingly by the newer types of plastic contact lenses which enable the sportsman to enjoy normal vision in safety The footballer featured in the news item is one of many who take advantage of this modern development in optical science

The basic principle of the contact lens has been known for *more than a century Sir John Herschel Astronomer* Royal suggested its practicability in 1827 Only in recent years however have the more serious limitations of this method been overcome through experience gained in the fitting of many thousands of lenses in Europe and North America

The lens is worn in close contact with the sclera (the white portion of the eyeball) It provides a new optically perfect anterior surface for the cornea without actually touching the sensitive corneal surface This clearance of the cornea makes it possible to wear the lens without discomfort The space between lens and cornea is filled with a fluid similar to the tears

By means of contact lenses focal errors of vision may be corrected with a degree of accuracy unequalled in many instances by spectacle lenses This unique feature of contacts is particularly valuable when the cornea has been damaged by disease or injury In keratoconus for example (a conical protrusion of the cornea) they offer by far the best means of visual improvement giving almost miraculous results in many cases previously considered hopeless

Demography - Science and Administration

R. R. KUCZYNSKI

I *The Beginnings of Demography*

UNTIL ten years ago the word 'demography' was [illegible] in this country [illegible] the [illegible] and [illegible] the [illegible] [illegible]tional Statistical Institute, [illegible] *[illegible]aphiques* published by [illegible]

Dictionary still defined demography as 'statistics of births, diseases etc, illustrating condition of communities,' while demography, as is evident from the word itself, aims primarily at a description of the population, using, of course, if available, censuses, birth, marriage, death, and migration statistics, and occasionally also statistics of diseases However, in recent years 'demography' has been used more frequently and more correctly, and the University of London even appointed (in 1938) a Reader in Demography

Demography, like every other science, has to do with methods and with results A few scholars have been interested only in the development of methods by which the basic data may be correctly interpreted, and the demographer owes much to those pure mathematicians Among demographers who are all, of course, interested in interpreting results a certain number have contributed to the development of methods

The first man who ever made a demographic study was the London haberdasher John Graunt His little book *Natural and Political Observations upon the Bills of Mortality*, published in 1662, was a remarkable achievement His basic material consisted of the weekly London 'Bills of

almost complete invisibility (an undoubted asset in social and stage life) and the visual benefits mentioned above Among their disadvantages are comparatively higher cost, the limited period of use, and physical unsuitability of the eyes in certain cases

Demography - Science and Administration

R. R. KUCZYNSKI

1. *The Beginnings of Demography.*

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The first man who ever made a demographic study was the London haberdasher John Graunt His little book *Natural and Political Observations upon the Bills of Mortality*, published in 1662, was a remarkable achievement. His basic material consisted of the weekly London 'Bills of

Mortality' which showed baptisms by sex and burials by sex, age, and cause of death He compiled all available Bills and analysed the content of his tables, which covered many decades, most thoroughly and with a vast amount of common sense He even went so far as to construct a life table for London This life table, of course, was most primitive and inaccurate – about as inaccurate, I should say, as the recent official life tables for India or for Lagos His motive for 'deducing so many abstruse, and unexpected inferences out of these poor despised Bills of Mortality' was that 'the Art of Governing, and the true *Politiques*, is how to preserve the Subject in *Peace*, and *Plenty* [1] When Graunt published his pamphlet he had not the faintest idea that he had created a new science Demographic data, he thought, could be useful only to the Administration 'There seems to be good reason, why the Magistrate should himself take notice of the numbers of Burials, and Christenings, viz , to see, whether the City increase or decrease in people, whether it increase proportionably with the rest of the Nation; whether it be grown big enough, or too big, etc But why the same should be made known to the People, otherwise than to please them as with a curiosity, I see not '[2]

Graunt lived in an enlightened period The great importance of his work was at once recognized both by the State and by Science His name appears in the original list of Fellows of the Royal Society, which received its charter in 1662, and Sprat, in his History of the Society, speaks of 'the Recommendation which the King himself was pleased to make, of the judicious Author of *the Observations on the Bills of Mortality* In whose Election, it was so far from being a Prejudice, that he was a Shop keeper of London; that his Majesty gave this particular Charge to his Society, that if they found any more such Tradesmen, they should be sure to admit them all, without any more ado '[3]

The original list of Fellows contained also the name of Sir William Petty, who wrote *Essays in Political Arithmetick* and

other demographic studies [4] An able disciple of his friend Graunt, he was both more knowledgeable and more brilliant, but his contribution to the development of methods was not important. Edmund Halley, on the other hand, who joined the Society a few decades later, was hardly interested in demography as such, and his whole demographic work covers only eighteen printed pages [5] His great contribution was the discovery (in 1692) of a most ingenious method of constructing a life table He was not sufficiently explicit as to his data and the use he made of them, and his method has, therefore, been very often misunderstood Many of his successors in various countries committed grave errors in trying to apply it, while others introduced slight improvements But in a general way it may be said that Halley's method was for about 175 years the usual device for constructing life tables

2. *Science and administration*

England was the cradle of demography, and in the two centuries following the publication of Graunt's *Observations* England's contribution to the new science was equal to that of any other country But the position has since changed If a list were made of the hundred best demographers who set out on their careers during the last hundred years it would

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stats Since priority is given to all matters dealing with registration, in the continental statistical offices population statistics are not at such a disadvan

Mortality' which showed baptisms by sex and burials by sex, age, and cause of death He compiled all available Bills and analysed the content of his tables, which covered many decades, most thoroughly and with a vast amount of common sense He even went so far as to construct a life table for London This life table, of course, was most primitive and inaccurate – about as inaccurate, I should say, as the recent official life tables for India or for Lagos His motive for 'deducing so many abstruse, and unexpected inferences out of these poor despised Bills of Mortality' was that 'the Art of Governing, and the true *Politiques*, is how to preserve the Subject in *Peace*, and *Plenty*'[1] When Graunt published his pamphlet he had not the faintest idea that he had created a new science Demographic data, he thought, could be useful only to the Administration 'There seems to be good reason, why the Magistrate should himself take notice of the numbers of Burials, and Christenings, viz , to see, whether the City increase or decrease in people, whether it increase proportionably with the rest of the Nation, whether it be grown big enough, or too big, etc But why the same should be made known to the People, otherwise than to please them as with a curiosity, I see not'[2]

Graunt lived in an enlightened period The great importance of his work was at once recognized both by the State and by Science His name appears in the original list of Fellows of the Royal Society, which received its charter in 1662, and Sprat, in his History of the Society, speaks of 'the Recommendation which the King himself was pleased to make, of the judicious Author of *the Observations on the Bills of Mortality* In whose Election, it was so far from being a Prejudice, that he was a Shop keeper of London, that his Majesty gave this particular Charge to his Society, that if they found any more such Tradesmen, they should be sure to admit them all, without any more ado'[3]

The original list of Fellows contained also the name of Sir William Petty, who wrote *Essays in Political Arithmetick* and

He made similar complaints over and over again In his report for 1867 he said

> Two grave defects in the registers of the United Kingdom deprive them of much of their utility as pedigrees, and as records of facts for the solution of the great problems of population Neither the age of mothers at the births of each of their children nor the order of birth is recorded, so that the number of children borne by women at different ages, and in the course of their lives cannot be ascertained This defect was supplied in the first schedule of the Scotch Act but the important parts of the schedule were unfortunately discontinued after 1855[5]

It is pathetic to read in the Congress reports of the International Statistical Institute the appeals which Dr Farr made for the registrati[illegible]

[illegible]

where this question was not asked The birth schedule of 1837 remained unchanged until 1938, when Parliament in

[illegible]

data for many decades would have been as ample in England as in the British Dominions, the United States, France, Germany, Austria, Italy, the Scandinavian countries, etc, etc As he was second in command his country derived *only* very limited benefits from the last prominent demographer *it has* produced That he accomplished as much as he did was due to the fact that he was not only competent but also obsessed by an *urge for* research and a deep interest in demography None of his successors combined these qualities

Another cause of the deterioration of British demography is the lack of *contact* between administration and science On the Continent many directors of statistical offices are at the same time university teachers, they sometimes hold seminars in their office and teach the students the whole process of statistical technique It is quite usual for such students, after they have terminated their university studies, to be appointed assistants and later directors of municipal or other statistical offices, and to become in their turn

tage A Registrar General is rightly chosen according to his qualifications to function in this capacity, and he may never have dealt with population statistics before his appointment On the Continent a civil servant becomes director of a statistical office after having worked for many years either in the same or another statistical office, and it is inconceivable that he be appointed without having had experience in population statistics It may be argued that the Registrar-General has demographic assistants who are in charge of this section of his office's work But experience shows that this offers no solution of the problem The Registrar-General George Graham, in 1879, concluded his last annual report by saying 'Lastly, I must express to Dr Farr, whom in 1842 I had the good fortune to find here presiding over the Statistical Branch, my grateful acknowledgment of the important services he has ever since continually rendered He is acknowledged throughout Europe, the United States, East Indies and the Colonies as one of the first statists of the day To his scientific researches and reports I attribute any reputation that may have accrued to the General Register Office of England and Wales from the time he accepted office in this Department '[6] All this was perfectly true Dr Farr, in the Statistical Branch, made the best use of the basic data he got from the Registration Branch But his efforts to improve those data failed The birth registration form introduced in 1837, when the Registrar-General's Office was created, was quite defective From a demographic viewpoint it was much less satisfactory than, for example, the birth registration form introduced in Sweden in 1775 Dr Farr became early aware of that In his report for 1842 he wrote

.. no provision has yet been made for determining the simplest fundamental facts – the foundation of all reasoning on the subject – such as .. the ages of mothers of children Upon many of these [illegible]

[illegible] him[7]

at each subsequent census Questions relating to fertility were put only in 1911.

At the early censuses the omission of persons was apparently frequent, but from 1841 on the censuses in England have probably been as complete as in any other country. This does not mean that the omissions are altogether negligible There is, for example, a tendency everywhere to leave out young infants, and this tendency is strengthened in England by the habit of delaying the registration of births Thus the General Report on the 1921 census states

It may be observed that the [illegible]

It is impossible, of course, to estimate even approximately [illegible]

[illegible] numbers – that is, in numbers ending with 0 It may suffice to mention that, according to the 1931 census, there were 245,684 men aged 50, but only 215,999 aged 51 280,182 women aged 50, but only 240,793 aged 51 *Ages ending with the digit 7* are unpopular, while there is a marked predilection for ages ending in 8 According to the 1931 census, there were more men and more women aged 58 than aged 57 more men and women aged 48 than aged 47, more men and women aged 38 than 37, etc That the age statistics of many other countries are not so

university teachers Nothing of the kind exists in this country The scholar interested in population problems usually knows very little of the technique of statistical administration, he cannot appraise the technical difficulties and the cost of carrying out the proposals which he may suggest to the administration, he cannot effectively answer the arguments of the civil servant The administration on the other hand, focuses its attention on its immediate needs and is, as a rule, reluctant to acknowledge specific legitimate needs of the demographic scholar This, of course, does not affect the pure mathematician interested in methods but not in results As a consequence thereof, the foreign reader of a review such as the *Journal of the Royal Statistical Society* must be struck by the high standard of the purely mathematical contributions dealing with a fictitious population and by the scarcity of demographic papers The barrier *between administration and science deters the British* scholar from demographic research, another deterrent is the low standard of the official vital statistics, compelling him to resort to foreign statistics which are difficult to understand without a knowledge of foreign conditions and foreign languages The general level of demographic doctors' theses submitted to English universities is high but a demographic study of the authors would probably reveal that comparatively few are born in this country

3 *English census statistics*

Censuses have been taken regularly every ten years from 1801 up to 1931 These censuses furnish valuable information to demographers, sociologists, economists geographers and administrators I shall deal here only with those data which are of special interest to the demographer They refer to the sex and age composition of the population to marital condition, and to fertility The sex was ascertained from the first census onwards The ages of the population were obtained in 1821 and again from 1841 onwards The marital condition was asked for the first time in *1851*, and thereafter

at each subsequent census. Questions relating to fertility were put only in 1911.

'At the early censuses the omission of persons was apparently frequent, but from 1841 on the censuses in England have probably been as complete as in any other country This does not mean that the omissions are altogether negligible There is, for example, a tendency everywhere to leave out young infants, and this tendency is strengthened in England by the habit of delaying the registration of births Thus the General Report on the 1921 census states

It may be observed [illegible]

It is impossible, of course, to estimate even approximately the numerical importance of the omissions at various ages. [illegible]

[illegible] ight be expected The mistakes in the returns on sex, to be sure, are undoubtedly few But the age data are less satisfactory There is in England, as everywhere, a tendency to report age in round numbers – that is, in numbers ending with 0 It may suffice to mention that, according to the 1931 census, there were 245,684 men aged 50, but only 215,999 aged 51, 280,182 women aged 50, but only 240,793 aged 51 [illegible]

[illegible] than aged 57, more men and women aged 48 than aged 47 more men and women aged 38 than 37, etc. That the age statistics of many other countries are not so

defective as those of England is due to the fact that in their census forms they do not ask for the age at the last birthday, but rather for the date of birth. It seems desirable that henceforth England should follow their lead in this respect.

Misstatements of marital condition are also quite frequent. The large excess of married women over married men which appears at every British census can be explained only in part by the fact that the number of married members of the Army, Royal Navy, and Merchant Service who are temporarily abroad exceeds the number of married foreigners who are temporarily in this country and have left their wives at home. It seems that tens of thousands of women report themselves as married though they are not. But a much graver defect is the inadequacy of the statistics of divorced people. Until 1921 all persons over 15 years were asked to state in the census forms whether they were single, married, or widowed. As to divorced persons, it was evidently left to their discretion which of these three alternatives they liked to choose, and if by any chance they were obstinate enough to reveal their actual marital condition they were probably counted as widowed. In 1921 a discreet attempt was made to identify divorced persons. The heading of the column relating to marital condition now read

> For persons aged 15 and over write Single, Married, Widowed, or if marriage dissolved by divorce write D.

The innovation was introduced with great reluctance and with the conviction that it would prove to be a failure. The report states

> At the 1921 census an attempt was made for the first time in this country to ascertain the number of divorced persons in the population.
>
> The total number returned in this category amounted to 16,682 in all, of which 8,464 were males and 8,218 females. It is greatly to be feared, however, that doubts as to the value of such returns, which were felt and expressed when it was first decided to include the inquiry in the general census questionnaire, have proved only too well founded, for from an examination of the records of the divorces which have been granted year by year, after making full allowance for reductions in the numbers by mortality and by a very high remarriage rate, the

[illegible] the

[illegible]

The number of men reported as divorced was then slightly greater than the number of women Since the remarriage rate of divorced men is much higher than that of divorced [illegible]

the divorced females 19,169 It will be interesting to read the official comment on these figures in the General Report, which has not been published as yet

From a demographic standpoint the 1911 census is still to-day the most valuable of all because it included questions [illegible]

died The question about the duration of marriage was answered incorrectly by a very large number of wives The tendency to concentrate on round numbers – 10, 20 30 40 – wa[illegible]

tua[illegible]

she[illegible]

co[illegible] 0-1, 1 2 and 2 3 years to the number of marriages concluded in the three years preceding the census was 68 5[illegible] and 89 per cent respectively, the understatement of the number of couples returned as married under one year being mainly due to a desire to conceal ante-nuptial conception. The instruction to return [illegible] the children of the present marriage was often disregarded O[illegible] the other hand many mothers seem to have [illegible]itted in their statements children who died young [12]

The first census embodying fertility questions had been taken in 187[illegible] in Massachusetts and many other countries followed suit The decline in the birth rate made, of course,

tion nearly twice that of England and Wales and with an area more than fifty times as large But we knew that we had to do it, and all the volumes, tables and text, covering nearly 10 000 large, closely printed pages, were published within the prescribed time limit

4 *English vital statistics*

Civil registration of births, marriages, and deaths was started on July 1st, 1837 The records are probably as complete as in any other country Birth registration, to be sure, was somewhat defective prior to the introduction of compulsory registration in 1875, but it is safe to say that nearly all children born thereafter have been registered, though often with great delay Death registration was almost complete from the outset Marriage statistics, of course, are absolutely complete, since, while people may be born or may die without being registered there is no marriage without registration As to accuracy the vital statistics suffer from defects similar to those of the census statistics The age at death is too often reported in numbers ending with 0 There is also, at least among middle-aged persons, a predilection for ages ending in the digit 2. Here again the remedy lies in asking for the date of birth instead of the age in years.

Until the new Population (Statistics) Act came into force, the Registrar-General's *Statistical Review* showed merely the number of male and female legitimate and illegitimate live births and still births, registered in each quarter From July 1st 1938, on the *Statistical Review* shows in addition the births by order of birth, age of mother, and duration of marriage The *Decennial Supplement* gives in addition data about fertility by occupation in the period centring around the census The *Supplement* dealing with the year 1921 was [illegible] in 1927 the volume which is to cover the years [illegible] set But the records of the [illegible] use has been [illegible] ord- ed the date of birth and the date [illegible] n the

the demand for such enquiries ever more urgent, and between 1920 and 1936 alone fertility censuses were taken in France (1921, 1926 1931, and 1936), Holland (1920 and 1930) Norway (1920 and 1930) Hungary (1920 and 1930) Estonia (1922 and 1934) Spain (1920 and 1930) Italy (1931), Czechoslovakia (1930), Germany (1933) the Union of South Africa (1921 and 1926) Southern Rhodesia (1921 and 1926), Northern Rhodesia (1921 and 1931), Australia (1921) New Zealand (1921 and 1936) But in this country no such enquiry has been made since 1911

Another grave defect which must be mentioned in this connection is the date of publication of the English census reports The fertility enquiry of 1911 was made throughout the United Kingdom The complete reports for Scotland and Ireland were both published in 1913 For England and Wales a first volume containing a number of basic tables was published in 1917 the second volume containing all other tables and the text was published in 1923 I have already mentioned that the text volume of the 1931 census is not yet available The volumes published so far contain merely tables This it seems to me is an intolerable situation which should be remedied and could be remedied easily I happened to be connected with the United States Census of 1900 The publication of the 1890 census reports had been very slow But Congress was not willing to run a similar risk again The Census Act of March 3rd 1899 provided therefore

The only volumes that shall be prepared and published in connection with the Twelfth Census, except the Special Reports hereinafter provided for shall relate to population mortality and vital statistics the products of agriculture, and of *manufacturing and mechanical* establishments and shall be designated as and constitute the Census Reports which said reports shall be published not later than the first day of July nineteen hundred and two

We then had barely two years for the preparation and publication of the reports not only of a most elaborate population census but also of a most intricate census of agriculture and of manufactures in a country with a popula

regular publication of these standardized death rates The correct death rate derived from the life tables has decreased in the last sixty years from 23 to 16 or only by about 30 per cent England, which in the 1880's had a lower mortality than, for example, Germany, Holland, and Switzerland, had in the 1930's a higher mortality than those countries The time that is wasted in computing misleading standardized death rates could not be better used than in studying why the progress achieved in lo...

1838-54, 1871-80, 1881-90, 1891-1900, 1901-10, and 1910-12 Since then tables have been published only for 1920-2 and 1930-2 While the earlier tables comprised all years from 1871 to 1912, the recent ones cover only six of the thirty two years elapsed since 1912 Formerly the bad years were taken with the good years It is obvious that the results of the new procedure, which completely ignores not only the war years but also such a bad peace year as 1929, are much less conclusive The existing life tables should be supplemented without delay by a life table for females for 1911-20, and by tables for each sex for 1921-30 and 1931-9 The necessary data are all available in the Registrar-General's Office, and by using modern short-cut methods which yield results sufficientl...

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d[illegible]

statistics were until 1938 As in the case of the death statistics it is not so much the tables showing the basic figures which need modification but rather the published rates and averages The R[illegible]

Review

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persons ... sixty or seventy years ago when the

or 22.7 per cent, while the number of actual deaths increased by 24,785, or 25 1 per cent It seems desirable, therefore that henceforth not only the births but also the deaths be classified throughout by date of occurrence.

The Population (Statistics) Act introduced only some questions of minor importance to be asked on the registration of death But the collection of details about deaths has been fairly ample for many years, and the mortality statistics of England compare favourably with [illegible] tries. I would [illegible]

[illegible] The [illegible] is meant to convey a better [illegible] of the trend of mortality than the crude death rate, has decreased from 20 in 1876-80 to 9 in 1935-9 The crude death rate has decreased only from 21 to 12 This crude rate is no adequate gauge of [illegible]

[illegible] now more [illegible] years ago, the crude death rate overstates the decline of mortality The official standardized death rates are those which would have been recorded if the age composition of the population had been the same as in 1901. All depends, of course, on what year is taken as a standard, and it so happens that by choosing the year 1901 the decline of mortality in the last sixty years is overstated still more than by a comparison of the crude death rates. To compute what the death rates would have been sixty years ago and what they would be now if the composition of the population by age at both dates had been that of 1901 is perfectly futile. It is just as futile as to compute what would have been the death rates then and to-day if, both in the late seventies and now, the composition of the population by occupation had been the same as in 1901 But the computation of such standardized death rates is not only [illegible] nuisance [illegible] to co [illegible]

to the births which occurred in each year and making allowance for a continuing improvement in survivorship conditions'[34] In his Statistical Review for 1938 he had included a net reproduction rate computed according to the principles accepted all over the world (and adopted by the League of Nations and the International Statistical Institute), which imply that such rates should be computed on the basis of current fertility and mortality. His new rates take no account whatever of current mortality Although

[illegible]

estimates of future survivorship conditions are uncertain; they tend to overstate reproduction because they disregard fluctuations in mortality. But if they were recomputed on the basis of current mortality they would be most useful.

'A start, no doubt, has been made in the course of the last few years to increase our knowledge of the demographic position of England. But much has still to be done in order to enable the Royal Commission to examine the facts relating to the present population trends' A few things have been suggested before, such as the computation of life tables and [illegible]

of [illegible]

the [illegible]

up [illegible]

[illegible] taking of a special fertility (or family) census which would fill many gaps caused by the numerous sins of omission committed in the course of the last decades Such a fertility census would convey a comprehensive picture of essential demographic facts upon which (to use Farr's words of 1843) 'the greatest ignorance prevails,' for example, the incidence of childlessness, the spacing of births, fertility differences between occupational and social groups,

Since the appointment of the Royal Commission the position has improved considerably

1 The results of the emergency census taken for purposes of national registration on September 29th, 1939, were published in the spring of 1944 The report shows the civilian population by sex, age, and marital condition The returns are less trustworthy than those obtained at the general censuses, and the data for men are particularly defective inasmuch as they exclude (for England and Wales) about 900,000 non civilians, but our knowledge of the age composition and the marital conditions of females has become much more up to date

2 The Government published in the summer of 1944 data for 1940 collected under the Population (Statistics) Act, similar figures for 1939 were published in the autumn of 1944, and shortly thereafter for the second half of 1938 [13] The tables for 1938 are accompanied by a covering report which shows the gross and net reproduction rates for 1938 Unfortunately the text is written in the same vein as the White Paper on current trends of population The Registrar General evidently thought that the main object of such a report was to fight what his Medical Statistical Officer called that lamentable sense of national inferiority from which a large section of the population now seems to be suffering '[14] The essence of his argument is that the population problem is not serious since a population decline could be prevented by encouraging marriage and particularly early marriage For 1939 and 1940 only tables have been published but no rates and no text It is to be feared therefore that in their present state these statistics will be of little use to the members of the Royal Commission However the basic data are now available and it should not cause insurmountable difficulties to relate them to other data hidden in the Registrar General s Office and to provide an unbiased interpretation of the figures

3 The Registrar General in the spring of 1944 published for 1934-43 'approximate reproduction rates corresponding

to the births which occurred in each year and making allowance for a continuing improvement in survivorship conditions'[15] In his *Statistical Review* for 1938 he had included a net reproduction rate computed according to the principles accepted all over the world (and adopted by the League of Nations and the International Statistical Institute), which imply that such rates should be computed on the basis of current fertility and mortality His new rates take no account whatever of current mortality Although in 1940 [illegible]

year in year-out a steady/gradual improvement in survivorship conditions' These rates are not comparable with those of any other country, they are speculative because all estimates of future survivorship conditions are uncertain; they tend to overstate reproduction because they disregard fluctuations in mortality But if they were recomputed on the basis of current mortality they would be most useful.

A start, no doubt, has been made in the course of the [illegible]

[illegible] ing to the present population trends.' A few things have been suggested before, such as the computation of life tables and nuptiality tables, of gross reproduction rates and of genuine net reproduction rates and a proper analysis of the statistics collected under the Population (Statistics) Act up to 1944 But the most important task of all is the immediate taking of a special fertility (or family) census which would fill many gaps caused by the numerous sins of omission committed in the course of the last decades. Such a fertility census would convey a comprehensive picture of essential demographic facts upon which (to use Farr's words of 1844) 'the greatest ignorance prevails,' for example the incidence of childlessness, the spacing of births, fertility differences between occupational and social groups,

than in any British Dominion or Colony or in any foreign [illegible]

Wales and the population was nine times as large Yet, the forty nine volumes of that Indian census which included an admirable text of several hundred thousand words were published within thirty months after census date Would anyone suggest that it is easier to take a census in India, that it is easier there to instruct the supervisors and the [illegible]

anyone suggest that with the present organization it would be possible here to achieve what has been achieved in India?

Difficulties, it is true, may arise in finding the adequate personnel for the new organization The leading men should be competent unbiased, eager, and preferably *young*. It is here that Science can play an important part Our universities should establish chairs for demography and the students of demography should be thoroughly trained in statistics This training would enable them to find a position as statisticians if they fail to secure employment as demographers But the demand for demographers will be considerable in the future. The increasing importance of the population problem will afford many opportunities of doing useful work in this country, and the great development schemes in the Colonies cannot be carried out effectively without the assistance of expert demographers.

In the field of demography as in many other fields the Administration [illegible] is that [illegible] comp[illegible] which [illegible] by which the basic demographic data may be correctly interpreted but he himself cannot collect those data They can be collected only by

the Administration, and his chances of getting the data he needs will obviously be much greater if he contributes towards the education of the future personnel of the Administration

NOTES

1 *Natural and Political Observations*, p 72 London, 1662

2 See *ibid*, p 12

3 Thomas Sprat, *The History of the Royal Society of London, for the Improving of Natural Knowledge*, 3rd ed, p 67, London, 1722

4 See *The Economic Writings of Sir William Petty*, ed by Charles Henry Hull 2 vols Cambridge, 1899

5 'An Estimate of the Degrees of the Mortality of Mankind, drawn from curious Tables of the Births and Funerals at the City of Breslaw,' *Philosophical Transactions*, vol 17, No 196 Jan 1693, pp 596-610 'Some further Considerations on the Breslaw Bills of Mortality,' *ibid*, No 198, March 1693, pp 654-6

6 *40th Annual Report of the Registrar General of Births, Deaths, and Marriages in England* (1877), p xl

7 *6th Report* (1842), p xxvii

8 *30th Report* (1867) p 222 See also *14th Report* (1851), p xii, *16th Report* (1853), p x, *27th Report* (1864) pp xix xx, *Supplement to 35th Report* (1872) p xi

9 See, for example, *Congrès International de Statistique à la Haye, Compte-rendu des travaux de la septième session, seconde partie*, p 533 The Hague, 1870

10 *Census of England and Wales 1921 General Report with Appendices*, p 78 London, 1927

11 *Ibid*, p 84

12 See R R Kuczynski *The Measurement of Population Growth*, pp 83-90 London, 1935

13 See *Statistical Review for the Year 1938 Tables Part II, Civil*, same for 1939 and for 1940 London 1944

14 *British Medical Journal* March 21st 1942

15 See *Births, Deaths and Marriages registered in the Quarter ended 31st December*, 1943, p 1

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What the Earth is made of

ERNEST TILLOTSON

Introduction

The earth is nearly a sphere having an equatorial diameter of 12,756.776 kilometres (7,927.06 miles) and a polar diameter of 12,713.7 kilometres (7,900.29 miles). It has a mass of 5.98×10^{24} kilograms (5,870 million million million tons) and it thus weighs 5.5168 times as much as it would if it were made solely of water. The corresponding ratio for average surface rocks is 2.6, and thus we see that the interior of the earth must be made of material much more dense (heavy when we take unit volume). Our knowledge of the interior of the earth is obtained by inferences from observations and experiments made within the uppermost 4 or 5 kilometres (3 miles) of thickness or depth. In our task of finding what the earth is made of we therefore proceed by making a mental model of the earth, the parts of the model being constructed from our observations and deductions from experiments. We can then amend this model if necessary as new facts come to light. That we do alter it from time to time and that we are still prepared to do so, and to discuss alternatives, indicates that our present model is not perfect. Its lack of perfection is caused by our observations being incomplete, and some of our deductions faulty. Let us examine the 1948 earth model, and the observations and deductions used in the making of it.

A glance at a cliff face shows the rock to be arranged in layers and these layers to be concentric with the earth's centre. It is not therefore a wild flight of fancy to imagine the earth to be made up of concentric spherical shells something like an onion, these shells increasing in density as we go towards the centre (see plate 20). The next obvious

step is to try to discover how thick these shells are individually, and of what kind of material they are likely to be made Let us first look at the outer 4 or 5 kilometres thickness

What the geologist has to say

When the soil and sub soil have been cleared away from part of the earth's surface by wind, streams, glaciers or other natural agencies, or by the hand of man as in quarries and mines, we can see the rocks Rocks may be classified into three types, sedimentary, igneous and metamorphic. Sedimentary rocks are those which have been deposited by the agency of wind or water, igneous rocks have been formed by volcanic action that is they have been molten, and metamorphic rocks are either of the above altered by heat or pressure or both Sedimentary rocks may be recognised by examining the individual mineral grains of which the rock is composed, when these are seen to be water- or wind-worn, and by the presence in sedimentary rocks of the remains of the fishes, animals or plants which were living at the time when the rocks were deposited and which are now found as fossils By examining these fossil remains and by noting carefully the relative positions of undisturbed horizontal beds as they occur one above the other we can distinguish a sequence, which, in the British Isles has been worked out, and the groups of rocks given names as follows: at the base of the sequence and therefore the oldest sedimentary rocks, pre-Cambrian, and above this in order as the rocks were deposited more and more recently, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene and Oligocene, Pliocene and Recent Igneous rocks may be recognised in that the individual mineral grains have not been rounded, the rocks in mass are not arranged in layers or strata, but they have been intruded into the surrounding sedimentary rocks and they do not contain fossils The character of metamorphic rocks is indicated by their position amongst other rocks, i.e., near intensely contorted strata or igneous in-

trusions, and by their appearance in hand specimens or in thin slices under the microscope If at one time they were sedimentary and contained fossils these will have been altered beyond recognition The examination of the individual mineral grains singly or in thin sections under a microscope assists identification

The various minerals needed for our civilisation are found concentrated in ore bodies, which makes commercial exploitation possible The presence of these minerals in the crust as a whole is often in very small proportions For example iron is present to the extent of about 5 per cent by weight of the whole crust, copper 0 01 per cent and lead 0 002 per cent The concentration of minerals into ore bodies is often by volcanic action, but occasionally by water sorting or other natural process

The thicknesses of the individual strata vary greatly from one to another, and even the same stratum is of different thickness from place to place Sometimes one or more strata may be entirely absent, causing a non sequence or unconformity at that point At the thickest places as in the Alps, Andes, Himalayas and Rocky Mountains the total thickness of sedimentary rocks may be 4 kilometres (2½ miles) whilst under the Pacific Ocean it is supposed that they are entirely absent

What the geophysical prospector tells us

When a geologist examines the stratified rocks at the earth's surface and finds them dipping or their bedding planes sloping into the ground he can take the angle of dip and with a knowledge of the topography draw a section to show what happens to them underground In this he is assisted by other observations of other strata in the district, and possibly by the reappearance of the original strata (recognised by fossil assemblage) further away This is called extrapolating from known data to unknown regions The only real proof that his extrapolations are justified is by drilling and examining the cores so obtained This is very

expensive and nowadays there are cheaper ways of testing geological inferences obtained in the above manner These less expensive methods are called geophysical prospecting, because we make use of the physical properties of the rocks and examine them with the apparatus which physicists normally use in their laboratories and observatories The four chief methods are magnetic, electrical, gravitational and seismic We will examine these methods in some detail, particularly the seismic method, as they are also useful for the larger work of probing the deep interior of the earth

The magnetic method depends upon the magnetic susceptibilities of various minerals in the rocks The presence of deposits of iron, nickel or cobalt ore can readily be detected by this method even if they are buried to a depth of over 1,500 metres (5,000 feet) Ores which occur in association with, say, magnetite or pyrrhotite can also easily be located by this means, though the percentage of iron present in a mineral is not the only criterion of its magnetic susceptibility Occasionally certain igneous rocks such as basalt, diabase, diorite or serpentine are more strongly magnetic than, say, haematite, which contains a higher percentage of iron In magnetic surveys the vertical component of the earth's magnetic field at a given point is usually found, as this in practice is more sensitive for the purpose of locating underground deposits or determining tectonic structures than finding the horizontal component In most instruments of the type used in the field this vertical magnetic force is compared with an opposing force in the instrument due to, say, gravity, torsional or bifilar suspension or the magnetic force of an auxiliary magnet The magnetic survey is the quickest and cheapest of all surveys It does not need a trained observer and is independent of topography Its limitations are due to the fact that only some rocks have magnetic properties It has proved extremely useful in such countries as Sweden

The gravitational method of obtaining evidence concerning underground structures depends on the variations of

density of the rocks as we go from place to place The work is not carried out by means of a pendulum which would measure the absolute value of gravity in any place, but usually by means of a torsion balance which measures horizontal *variations* in gravity The first effective torsion balance was constructed by Baron Roland von Eötvös Professor of Physics at the University of Budapest, in 1888 One type of the Eötvös torsion balance consisted of a light horizontal beam with equal masses of platinum at each end – one actually at one end of the beam and the other suspended at a depth of about a metre from the other end of the beam The system was suspended from the mid point of the beam by means of a delicate suspension wire, the torsion in which acted in opposition to the tendency of the earth to rotate the beam into one definite position The suspended beam carried a mirror by means of which, in association with a scale mounted on a separate stand a telescope could be used to observe changes in the position of equilibrium of the beam The greatest success of the instrument lies in delineating the extent of large bodies of very high or very low density when these occur fairly near the surface The boundaries *of salt domes* associated in some parts of the world with petroleum deposits, can be mapped efficiently, after the necessary corrections for the effects of surface features have been applied.

Electrical methods have been used to determine the depths and dips of hidden layers of rock and are based on the differences in electrical conductivity between adjacent rock bodies These differences may be very large and hence there is a greater range in this method than in any of the other methods. The oxidation of certain sulphide ores produces natural earth currents, but in other cases it is necessary to set artificial electric currents in the earth and ascertain their effects

The [illegible]

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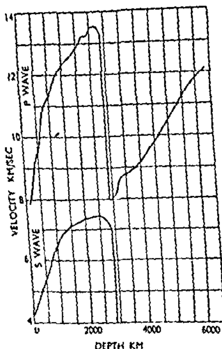


Fig 12 — The speed of travel of both S and P waves increases as we go deeper into the Earth, until the core is reached.

of the weight and the surroundings, a few thousandths of an inch, is magnified and then recorded on paper fixed to a revolving drum Time marks are also put on the paper.

There are various ways of arranging the work in seismic prospecting, but here we will consider only two ways —

by Tertiary strata If we fire a charge of explosive at S (Fig 13) and have seismographs at A, B and C, equal

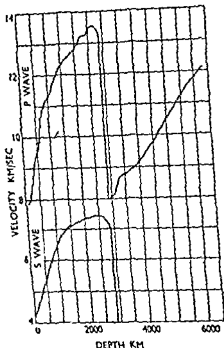


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There are various ways of arranging the work in seismic prospecting but here we will consider only two ways – refraction shooting and reflection shooting Suppose in the first instance that the area has been geologically surveyed and that a salt dome is to be expected. We first wish to find the horizontal extent of the salt which is surrounded by Tertiary strata If we fire a charge of explosive at S (Fig 13) and have seismographs at A, B and C, equal

the future The cost is fairly high but it pays dividends by its efficiency and it is much cheaper than drilling. Relatively simple geological structures such as salt domes, anticlines, and horizontal strata have been dealt with successfully up to the present time The earthquake waves are produced artificially at a known instant by firing electrically a quantity of explosive In the neighbourhood of the Gulf of Mexico, when prospecting for salt domes, 70 to 90 kilograms (150 to 200 lb) of T N T are buried 4 to 6 metres (14–20 feet) underground and fired electrically In that part of the world the hole is sometimes left unfilled In England and more populated areas less explosive is employed, though the people of Leyland in Lancashire thought they had experienced a natural earthquake when a shot was fired in a 30 metre (100 feet) borehole in the neighbourhood when prospecting for oil on Sunday morning, 21 July, 1946 The action of the explosive is to generate at least two types of waves In the first type, called *primary* (P), the particles move backwards and forwards in the direction of the wave, which is thus longitudinal It is of the same nature as a sound wave though often the frequency of the wave is such that human beings cannot hear it, and an instrument is required for its detection and reception The second type of wave is called secondary (S), and as the wave passes any point the particles in its path move to and fro at right angles to the path It is thus a transverse wave, and is slower than the P wave Moreover it must be transmitted through solids Liquids and gases cannot transmit S waves In seismic prospecting at present P waves only are used, though in future S waves may be employed The instruments used to detect these waves, which are similar to two waves present in natural earthquakes, are called seismographs and the records obtained by them seismograms In principle, the horizontal seismograph consists of a weight fixed at one end of a nearly horizontal rod, which is pivoted at the other end When the earth quakes everything moves except the weight, which stands relatively still The relative movement

layer of the earth, which is the one handled by geologists This portion of the earth is called by geophysicists the sedimentary layer It is largely sedimentary in the geological sense as it is composed chiefly of such rocks as limestone, sandstone, shale and clay, which are the products of weathering and reconstitution of the original stony surface material We will now probe deeper

The interior

The basement complex of pre Cambrian rocks, about 1,500 000,000 years old, is visible in Finland and consists there of 52 5 per cent by weight of granite, 21 8 per cent mixtures of granite, sediments (the earliest deposited on Earth) and old Volcanic rocks, 4 0 per cent granulites, 9 1 per cent schists (a metamorphic rock whose crystals are distinguishable to the naked eye, which is conspicuously thinly foliated and in which felspar is absent), 4 3 per cent sandstones and quartzites 0 1 per cent limestones and dolomites and 8 2 per cent basic rocks unlike granite but once molten. It will be seen that it is truly granitic in composition originally largely igneous though partly sedimentary, but now largely metamorphic in texture There may be local variations in this metamorphosed mass of pre-Cambrian rocks, but according to seismological evidence it is fairly uniform in character and about 10 kilometres (6¼ miles) thick It is called the granitic layer and envelops the whole earth with the exception of the Pacific Ocean

Under the granitic layer is another uniform layer some 20 kilometres (nearly 12½ miles) thick which has a composition intermed ate bet [illegible]
in c [illegible]
alsc [illegible]
present [illegible] else in the Earth

The sedimentary, granitic and intermediate layers together form the Crust of the earth which took its name at the time when it really was considered to be the only solid

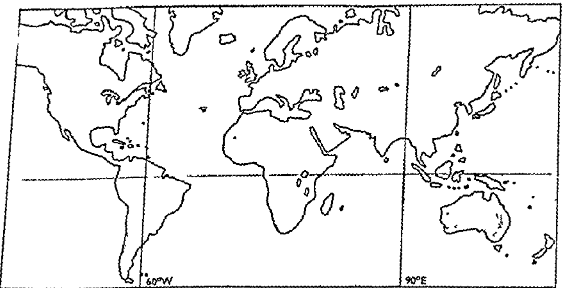
echoes of

the physical properties of the material at these high pressures keep the core stable, though at these temperatures and pressures it may constitute a transition region where physical and chemical properties begin to change strongly (These conditions are nothing like the conditions inside stars, however)

Temperatures within the earth

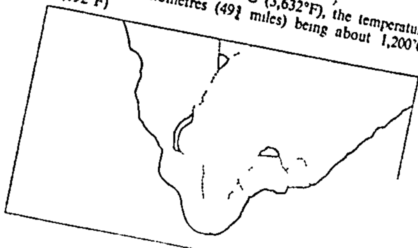
The temperature gradient in the crust of the earth is such that it gets about 1°C warmer in every 30 metres (1°F for every 18 yards deeper approximately) though there are large variations such as over salt domes and granite plugs and over basement rocks The heat current through the earth's surface is about 10^{-6} calories per second per square centimetre (3 69 × 10^{-6} British Thermal Units per second per square foot) and this appears to be largely accounted for by the estimated spontaneous production of heat by the known average radioactive mineral content of rocks in the uppermost 40 or 50 kilometres (25 to 31¼ *miles*) of the earth Furthermore, laboratory experiments tend to confirm that at high pressures rocks and minerals and metals are superconducting to heat and we are thus led to the conclusion that the interior of the earth no longer contributes to the heat flow through the surface Except for the outer most part of the mantle the temperature in the interior of the earth appears to be not far from the temperatures existing at the time when the crust solidified

When the earth was originally gaseous it is thought to have had a temperature of 6 000° absolute (5,727°C = *10,340 F*) the crust became solid after about 15 000 years and soon afterwards the surface cooled *sufficiently* for oceans to condense The temperature of the earth's centre

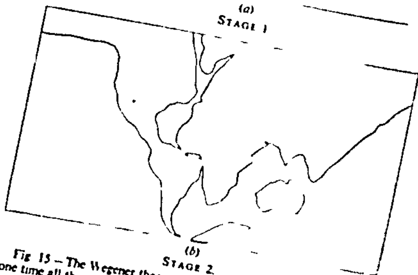


STAGE 3 Fig 16.—The world to-day the continents are separated But signs of the old state of affairs remain in the structure of the continents, and in the distribution of certain animals and plants

may now be just over 2,000°C (3,632°F), the temperature at about 80 kilometres (49¾ miles) being about 1,200°C (2,192°F)

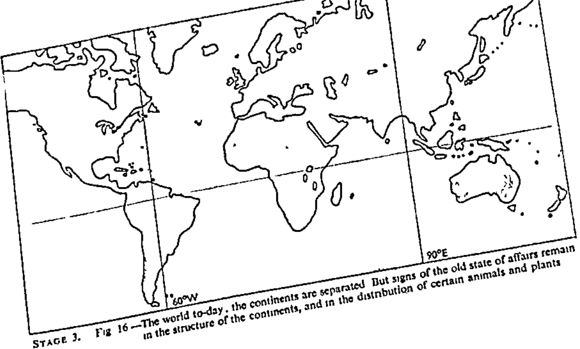


(a)
STAGE 1



(b)
STAGE 2

Fig 15 – The Wegener theory of Continental drift supposes that at one time all the continents of the world were bound in one great land mass (see (a)). Under the influence of the Earth's rotation they began to tear apart, attaining an intermediate stage (b)



STAGE 3. Fig 16.—The world to-day, the continents are separated But signs of the old state of affairs remain in the structure of the continents, and in the distribution of certain animals and plants

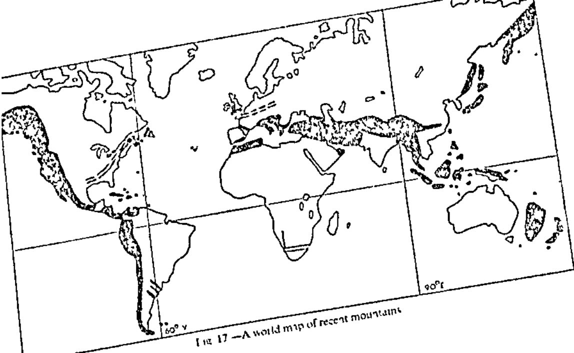
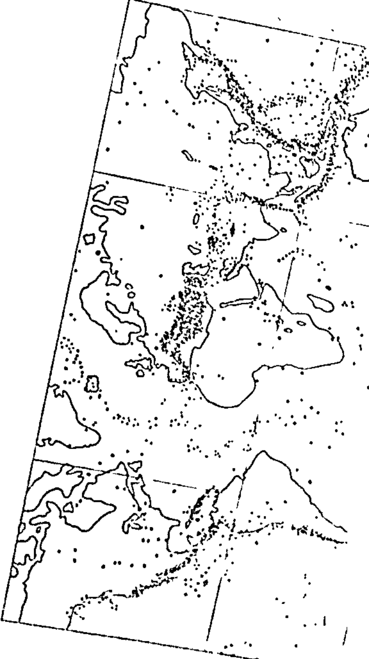


Fig 17 —A world map of recent mountains



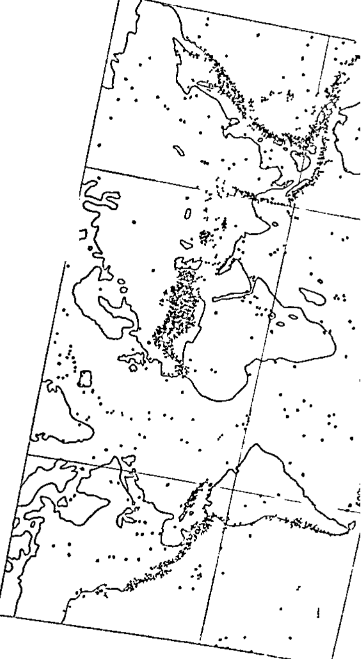
been caused in the same way as earthquakes which start at the earth s surface This point is, however, still under discussion If earthquake epicentres are plotted on a map according to their depth of origin interesting results are obtained We find that earthquakes with shallow foci, i e *0 – 100* kilometres (0 to 62½ miles) and intermediate foci, *i.e., 100 to 290 kilometres* (62½ to 181 miles) are closely associated with Tertiary *or more recent mountain* building (within the last 60 million years), whilst deep focus shocks, i e 290 to 700 kilometres (181 to 435 miles) are associated with pre Cambrian topography (1,000 000 000 years old)

What was the origin of the lateral forces in the earth's crust which *from time to time* have been responsible for all this movement and mountain building? Some have been due to the contraction of the earth s interior co ise quent on cooling, and some may have b-en caused by variations in *temperature* within the crust and upper mantle

others Let us take a look at the 'foundations of the crust, i e the upper part of the mantle.

The crust of the earth is often *called SIAL* on account of its estimated average composition by weight, wh ch is SiO_2 59 12 per cent, Al_2O_3 15 34 per cent, other minerals making

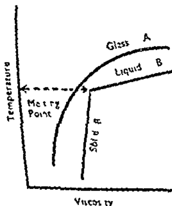
ing from the load The theory of isostasy concerns this hydrostatic support of the earth s crust by the mantle and states (in one of its forms) that each vertical column of the earth s crust, in regions that have not been recently dis turbed, which have a radius of at least 10 kilometres (6¼



Glass

E. L. LOEWENSTEIN

THE art of glass manufacture depends on melting together a number of substances, which, on cooling rapidly, will set to give a clear, transparent solid. From a physical point of view this corresponds more to the liquid than to the solid state. For example, the change from liquid water to solid water (ice) takes place at a definite temperature, and as long as both water and ice are present the temperature of the mixture will be 0°C or 32°F; with glasses this is not so on cooling, the viscosity increases continuously, and there is no definite temperature at which the glass can be said to solidify; similarly, on heating glass from room temperature it will soften more and more without any break in the temperature curve. This is best illustrated by means of a graph,



structure For example, beryllium fluoride is a glass-former, on substituting a smaller atom, e g. lithium, for beryllium, or a larger atom, e g bromine, for fluorine, we find that the substitutes are too small or too big respectively to fit into the network structure

It has been found that the ratio of the atomic radii of the cation to the anion must be approximately 0·3

The high stability of silica glasses compared with other glass-formers is ascribed to the fact that the ratio of the [illegible]

[illegible]

silicon atoms, furthermore, as no oxygen can hold more than two silicon atoms there is a certain flexibility in the joining together of SiO_4 tetrahedra. Hence the energy in the supercooled state is not very different from that in the crystalline state, and the tendency to devitrify is small.

If, however, other groups besides the SiO_4 tetrahedra are incorporated in the glass structure, the tendency to devitrify is increased

(2) Other constituents —The breaking up of the three-dimensional SiO_4 network by other constituents will lower the melting point of the [illegible]

[illegible]

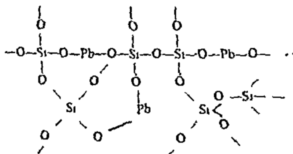
soluble in the glassmelt, and which has no tendency to [illegible]

[illegible]

incorporated into a glass without asking for trouble: the glass tends to devitrify even in the molten condition, and the finished article will be attacked rapidly by the carbon dioxide in the atmosphere

The continuity of the silica network can also be broken up by replacing some of the oxygens by fluorine. Oxygen is divalent and can, therefore, act as link between the individual tetrahedra, fluorine is monovalent and therefore cannot This method has its drawbacks as fluorides are not very soluble in the glassmelt, and the pots in which the glass is melted are badly corroded

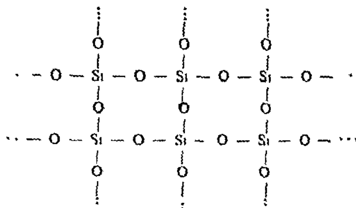
Calcium oxide (lime), barium, lead, zinc, and magnesium oxides do not break up the silica network, but thin out the tetrahedra, e g



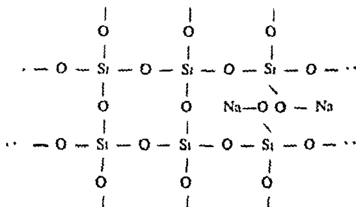
The extent to which these divalent metals can be added in the form of their oxides depends on the properties of the resultant glass, the solubility of the oxide in the glass, etc

by

ad... ...all quantities (up to 5 per cent), can form tetra



Silica in the vitreous state



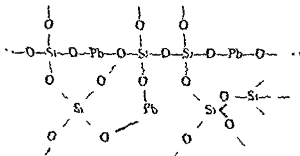
One molecule of sodium oxide, Na_2O, *has* entered the glass structure (The diagrams are projections on to a *plane, and do not represent relative distances, etc*)

It can be seen that there must be a limit to this process of breaking up the silica network; this limit is the formation of sodium *silicate* (waterglass). In glassmaking the limit is governed by the stability of the resultant glass, as a rough guide *not more* than 18 per cent of alkali oxide can be

incorporated into a glass without asking for trouble: the glass tends to devitrify even in the molten condition, and the finished article will be attacked rapidly by the carbon dioxide in the atmosphere

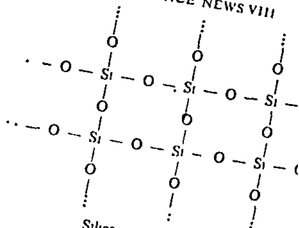
The [illegible] up [illegible] is [illegible] vidual tetrahedra, fluorine is monovalent and therefore cannot. This method has its drawbacks as fluorides are not very soluble in the glassmelt, and the pots in which the glass is melted are badly corroded

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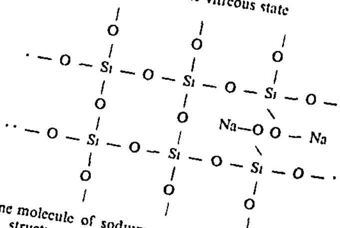


The extent to which these divalent metals can be added in the form of their oxides depends on the properties of the resultant glass, the solubility of the oxide in the glass, etc. With [illegible]

by [illegible] These, when added in small quantities (up to 5 per cent), can form tetra-



Silica in the vitreous state



One molecule of sodium oxide, Na_2O, has entered the glass structure (The diagrams are projections on to a plane, and do not represent relative distances, etc)

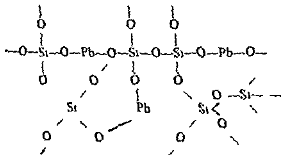
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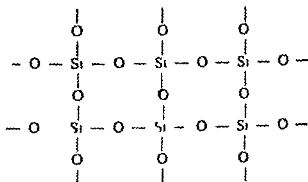
[illegible]

tetrahedra, e g

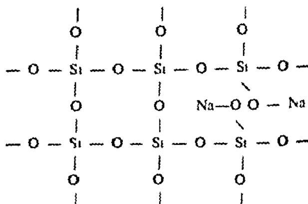


The extent to which these divalent metals can be added in the form of their oxides depends on the properties of the resultant glass the solubility of the oxide in the glass, etc [illegible]

[illegible] properties of most glasses can be improved by adding boric and/or aluminium oxides These, when added in small quantities (up to 5 per cent), can form tetra



Silica in the vitreous state



One molecule of sodium oxide Na O has entered the glass structure (The diagrams are projections on to a plane and do not represent relative distances etc)

It can be seen that there must be a limit to this process of breaking up the silica network this limit is the formation of sodium silicate (waterglass) In glassmaking the limit is governed by the stability of the resultant glass as a rough guide not more than 18 per cent of alkali oxide can be

Viscosity

DR A. E. BELL

VISCOSITY plays perhaps as large a part in the phenomena of everyday life as does friction – with which it is related It is in fact an effect we commonly exchange for friction when the latter is undesirable When we wish to reduce the drag between two metal surfaces, as in the moving parts of machinery, we introduce a thin layer of oil which acts as a lubricant. This replaces frictional loss of energy by a loss due to viscosity, but with a suitable lubricant the loss is much less, and the wear is eliminated The viscosity, or resistance to flow offered by the lubricant in the bearing, remains an unavoidable nuisance, but fortunately the viscosity of a liquid in practically all cases shows a marked decrease as the temperature rises, and this means that considerably less

a nuisance It is the same here with viscosity A reasonable amount of viscosity in a paint is an advantage since there is little flow during the time taken for the paint to harden. Too much will mean that the brush

hedra, which, being of a different size to those of silica will distort the symmetry of the SiO_4 groups in relation to one another This gives greater flexibility to the glass structure without breaking up the network

The sum total of all these effects on the originally symmetrical network is that it is impossible to represent visually and accurately the structure of a glass as was attempted above All that can be said on the subject is that the average position of the individual constituents is, say, one alumina group for every 50 silica groups, on the average every 24th Si – O – Si link is broken by an alkali atom, or for every three SiO_4 groups there is one lead atom thinning out the structure But we must remember that these are average positions, and deviations may be considerable It is impossible to picture the structure of glass the lines and chains of atoms are twisted and turned in all directions, the space allotted to each atom varies some are squeezed in, some have more breathing space, but, on the average, they just about fit in In technical language this has been termed a *random network structure, common also to mixtures of* liquid substances, this is another reason why the physicist calls glass a supercooled liquid

through a column of liquid What is wanted is a science of the subject, and straight away we see that to understand viscosity we need to know a good deal about the internal conditions, one might say the constitution, of liquids These, we know, are composed of molecules in fairly close contact and the forces between the molecules are unquestionably of electrical character Nevertheless we can get on quite well [illegible]

mean that we need to think only of the momentum of moving particles and the effects of forces on them, and not concern ourselves at all with electrons and protons, still less with those wave aspects of matter with which modern physics makes us familiar

At first sight it certainly seems as if liquids are really only very highly condensed gases or vapours You have only to cool and compress air sufficiently and, as we all know, it begins to liquefy Thomas Andrews' studied the change in the case of carbon dioxide in the sixties of last century and [illegible]

[illegible]ume with pressure at any given temperature and he did [illegible]fact plot the curve for the pressure/volume relation for a [illegible]ies of temperatures. The shapes of these curves or [illegible]thermals are shown in the figure Andrews found [illegible]

[illegible]o long as both gas and liquid were present in his apparatus [illegible]e pressure remained constant So soon as the gas was all [illegible]quefied it was found that great increases in pressure pro[illegible]uced no appreciable decrease in volume on account of the [illegible]ncompressibility of the liquid The result is that the left [illegible]and portions of the curves are all vertical.

The continuity of the two states can best be appreciated

These molecules slide over each other and one layer seems to cause a drag on the next through the entanglement of the chains This sliding of one layer over another, like the sliding over each other of the cards in a pack, is called a shear In Newton's great *Principia* of 1687 it was pointed out that the shearing force F is connected with the rate of shear, dv/dx, the viscosity η and the area of the layers A by the equation

$$F = \eta A \frac{dv}{dx}$$

and this is still the relation employed in measuring viscosity Since liquids commonly adhere very strongly to the surfaces of solids the flow of a liquid through a uniform circular tube involves the sliding of concentric layers over each other with the fastest movement at the middle and a zero velocity next to the wall This is what is called laminar or 'Newtonian' flow, and it means that the contour of the velocities across a section of the tube is of the form shown on the left



Fig 22

If we think of two flat layers A and B one centimetre apart, one moving relatively faster than the other by a velocity of one centimetre per second, then clearly A will exert a forward drag on B and B will exert a backward drag on A The force exerted per square centimetre of either layer is the viscosity of the liquid

In a general way it is clear that viscosity results from forces existing between the molecules as they pass over each other, and it is natural that physicists should be anxious to connect the viscosity of a liquid with the known properties of its molecules Measurements of viscosity are relatively simple and involve study of the rate of flow of liquids through fine tubes or the rate of fall of a small metal sphere

through a column of liquid What is wanted is a science of the subject, and straight away we see that to understand viscosity we need to know a good deal about the internal conditions, one might say the constitution, of liquids These, we know, are composed of molecules in fairly close contact and the forces between the molecules are unquestionably of electrical character Nevertheless we can get on quite well without concerning ourselves very much [illegible] of the [illegible] mole[illegible] mean [illegible] of the [illegible] moving par[illegible] concern o[illegible] with those [illegible] modern physics [illegible]

At first sight it certainly seems as if liquids are really only very highly condensed gases or vapours You have only to cool and compress air sufficiently and, as we all know, it begins to liquefy Thomas Andrews' studied the change in the case of carbon dioxide in the sixties of last century and he produced evidence to show that there is in fact a 'continuity of state' between the liquid and gaseous conditions of that compound. His method was to study the change of volume with pressure at any given temperature, and he did in fact plot the curve for the pressure/volume relation for a series of temperatures The shapes of these curves or isothermals are shown in the figure. Andrews found that for any temperature below 31°C there is a particular pressure at which the gas begins to liquefy this might be called the saturated vapour pressure for this temperature So long as both gas and liquid were present in his apparatus the pressure remained constant. So soon as the gas was all liquefied it was found that great increases in pressure produced no appreciable decrease in volume, on account of the incompressibility of the liquid The result is that the left hand portions of the curves are all vertical.

The continuity of the two states can best be appreciated

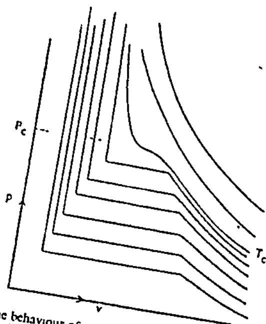


Fig 23 —The behaviour of carbon dioxide at different temperatures (see text below for explanation), P, pressure, V, volume

by running the eye from the bottom left-hand part of the figure up towards the top right-hand part The curve marked T_c is the isothermal for the critical temperature, and at the pressure p_c the conditions are in fact exactly intermediate. On watching a tube half-full of liquid carbon dioxide, as this temperature is reached it is seen that the liquid surface vanishes without the liquid having boiled away. This is because the liquid and gas states have under these conditions the same density and they are as a consequence indistinguishable. If we represent the liquid at a temperature lower than T_c by the densely crowded condition of the molecules in (a) and the gas at that temperature by (b), then at T_c and p_c the two pictures have to be made identical through the expansion of the liquid on the one hand and the compression of the gas on the other.

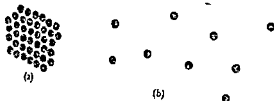


Fig 24

In his first scientific publication the Dutch scientist Van der Waals produced (1873) an elegant explanation of the facts discovered by Andrews and others. This successfully treated the liquid state as originating from the [illegible] and the combin[illegible] fo[illegible] eve[illegible] W[illegible] [illegible] predicted the change from the gaseous to the liquid state Today the old kinetic theory, according to which liquids closely resemble gases (in that their molecules are distributed in a purely random manner) has undergone considerable changes The nineteenth century chemists, it must be admitted, made remarkably good progress with a theory of solution in which the molecules of the liquid were treated as if they did not exist! The dissolved substance was supposed to have its molecules distributed just as if they were the molecules of a gas and for many purposes the solvent liquid could be forgotten. There was a certain paradox in saying that this success provided support for the kinetic theory, but so it was generally supposed to be. The phenomenon of Brownian movement was probably the best visual demonstration of the general correctness of the kinetic theory In this phenomenon, microscopic particles such as those found in Indian ink, or soil, or consisting of pollen grains or bacteria, when placed in water are to be seen under the microscope to be constantly vibrating or gyrating about fixed points so that the whole field of view is gently trembling in its appearance. Einstein gave a detailed

mathematical theory of the phenomenon, which is due to the unequal bombardments of relatively huge floating particles by the surrounding water molecules All that Brownian movement shows therefore is the existence of molecules in a state of vibration

It has not proved to be possible to give a mathematical account of viscosity on the basis of the old classical theory outlined in the preceding two paragraphs, and moreover there are other matters such as the existence of a more or less sharp melting point which are equally (or more) difficult. You have only to remove enough of the energy of the molecules of a liquid and they begin to take up a pattern and 'crystallise' When the crystals are melted how do we know that the pattern completely disappears? The answer appears to be that it quite often does not Professor G W Stewart[3] was the first to draw attention to the fact that where it was possible to obtain X-ray diffraction patterns for both the liquid and the crystalline states of a substance there was a general *resemblance between them* In the case of a crystal the pattern is formed by the scattering of a pencil of X-rays by the regularly spaced atoms, and it would be thought that the molecules (and thus atoms) of a liquid would be distributed *in so random a manner* that no pattern would be produced This proves not to be so, although the pattern is far less easy to detect than for the crystal

Following up this lead Professors Bernal and Fowler in 1933 *published a long paper*[4] *on the constitution of* water. They considered a wide variety of evidence including the X-ray scattering effects and they were able to conclude quite definitely in favour of a particular kind of 'quasi-crystalline' *structure for water near its freezing point Their views fit* in well with Stewart's theory that liquids have a 'cybotactic' structure, viz, that there are small aggregates of mole[illegible]s arranged as they would be in a cryst[illegible] water the same pa[illegible] tions in the ice [illegible] even though it extends over onl[illegible] [illegible] number of molecules at a time

The pattern is constantly forming and vanishing at any given point so that on the average only a certain degree of order prevails.

[illegible]

the solid phase, it does not, as in a gas, spend most of its life in comparative freedom and interact strongly with other molecules only occasionally'[5] Although the picture is not yet very clear the results from the experimental and theoretical sides seem to be in general agreement Useful evidence can for example be obtained from the study of glasses, which are simply liquids cooled down below their freezing points but without crystallisation having taken place It is as if the particles of the liquid had been frozen in their positions so that they can be studied at leisure (No doubt it is not really quite so simple as that)

It must be emphasised that an article of this size and scope cannot do more than present a general picture But enough has already happened to make it quite certain that the old kinetic theory of liquids is quite inadequate For the specialist there is a large review of the subject by the Russian Physicist Frenkel[6] Frenkel shows repeatedly that we must

[illegible]

gases.

Quite inevitably the new view of the liquid state has meant a considerable change in the explanation of viscosity In a flowing liquid it is now supposed that some of the momentum of one layer is transferred to the next (i.e. in laminar flow) through the operation of transient molecular forces of the sort found in crystals On the older theory, molecules were supposed to be lost from one layer to the next, and it was this which was supposed to bring about the transfer of momentum It is clear that the loss of faster moving mole

mathematical theory of the phenomenon, which is due to the unequal bombardments of relatively huge floating particles by the surrounding water molecules All that Brownian movement shows therefore is the existence of molecules in a state of vibration

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which orientate themselves in the electrical field of the ion There are, besides, ions of opposite charge always in the vicinity The result is an ionic atmosphere which is constantly shed and rebuilt as the ion moves through the liquid The effect on the viscosity of the solution has been calculated, notably by Falkenhagen, and some agreement between theory and experiment can be recorded

It is something of a relief to turn to the solutions of non electrolytes in solvents other than water, for here the conditions are a good deal simpler Here we almost certainly approach the state of affairs envisaged in Andrade's theory The molecules of the dissolved substance affect the viscosity in a way which depends in a relatively simple manner on their size and shape Staudinger, for example, uses the viscosity of a solution (e g in tetralin) in order to compare the lengths of molecules Thus he has shown that the relative alteration in viscosity

$$\frac{\eta \text{ solution} - \eta \text{ solvent}}{\eta \text{ solvent}}$$

depends directly upon the concentration of the dissolved substance and the size of its molecules Provided the substances compared are of the same chemical type the method gives a quick means of comparison of the sizes of molecules produced in the important process of polymerisation In polymerisation the chemist is causing small molecules to join up, usually in a head to tail fashion, to produce very large molecules and in the production of lubricating oils, and in the formation of substances for use in plastics this is of great economic importance

cules to a slower-moving layer would have this effect Frenkel, and in this country Professor Andrade, have worked out theories of viscosity which are more in line with the new ideas. As Professor Andrade expressed it, on the supposition of a 'transitory and fluctuating crystallisation,' or a temporary holding of hands between individuals of two parallel rows moving past one another, a theoretical equation can be derived which holds good for the viscosities of quite a number of elements in the liquid state. This equation is

$$\eta = K\sqrt{\frac{A T_m}{V_A}}$$

where A is the atomic weight of the element, T_m the melting point on the absolute scale of temperature, V_A the volume of the atomic weight expressed in grams and η the viscosity. The constant K has the value 5.1×10^{-4}. A modified equation can be applied to those liquid *compounds*, the molecules of which have sufficiently uniform fields of force around them.

Unfortunately water remains too difficult a problem. The water molecule possesses a field of force which is by no means uniform, and as Bernal and Fowler have shown the amount of 'order' in the liquid is relatively high. It would seem that the existence of cybotactic units must interfere with laminar flow as conceived in the simplest way. The consequence is that there is as yet no complete physical theory for the viscosity of water. Much work has been done, however, on the effect of dissolved substances such as salts.

The initial effect of all salts in very weak solutions seems to be to raise the viscosity. It is known on other grounds that the ions into which salts are dissociated have considerable restraining influences on each other's movements, and viscosity measurement of salt solutions does provide in fact a useful means of examining inter-ionic forces. The ions of salts are surrounded by large numbers of water molecules

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Group Psychotherapy

STEPHEN LESTRANGE

DURING the last generation the treatment of the mentally sick has made great advances No longer does the onset of serious mental illness mean the incarceration and the custodial care of the patient pending a possible spontaneous recovery Instead, there is an almost universal counsel of hope and active therapeutic measures are available. The dramatic empirical success of the new physical treatments – electrical treatment, insulin therapy and 'Mind Surgery' – must not be allowed to obscure the more solid advances which have been made in the understanding and treatment of the milder forms of mental illness Mental illness – 'Insanity' – still has a great deal of stigma attached to it, but with the increase in knowledge of the function and structure [illegible] realise more often that nervous symptoms can and should be treated

Knowledge of the how and why of mental disorder first [illegible] knowledge which is widely accepted or open to direct proof remains extremely small Freud recognised that [illegible]

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3 *Chemical Reviews* 6 (1929) 483
Reviews of Modern Physics 2 (1930) 116
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inhibition and reduction (sublimation) of many primitive [illegible] There must be [illegible] wishes and [illegible] flict with his fellows a kind of *thermostatic control*, with the regulator set at a conventional level of permitted self seeking This control mechanism may break down in several ways The individual may refuse, for instance to accept the sacrifices imposed by the community and become a criminal or a revolutionary More often *open conflict is unsought*, and arises either because of a constitutional weakness of the personality or because the problem to be solved becomes too great This failure to control the situation leads either to mental illness or the stress may cause apparently physical disease such as peptic ulcer or colitis In the causation of mental illness external strain generally interacts with a poor personality structure The balance between these two factors is well illustrated by the experience of war time Here the external stress is increased and may become so great that the most stable personalities will react with marked neurotic symptoms

Illness begets its own treatment. Psychotherapy is the combined attempt of the patient and his physician to unravel the causes of the conflict and attain an understanding of the underlying basis of the symptoms Relief through psychotherapy can be obtained by three main methods

Removing the cause many of the aetiological factors lie in childhood or even further back – in the inherited make up of the patient – and it is of course impossible to remove them The burden of real and present troubles is however, often a large one, for the neurotic tends to accumulate failure Adjustment of the environment is therefore an important part of the treatment of the patient and it is the plight of the social worker not that there is so little to do, [illegible] A patient who suffers from claustrophobia may find the long journey to work in a crowded train a terrible ordeal His impulses to jump from the

unconscious resistance Secondly, these fallacies are almost always half truths, and there is consequently a lot of evidence to bolster them up women are good and they are evil

One further example of a type of misconception of major importance is that children are almost always taught absolute standards of right and wrong Their criteria of ethical behaviour are often excellent, but the ideals are unfortunately painted in strong blacks and whites and much unnecessary conflict is engendered by this distortion The man who believes that women are pure is unable to reconcile this with the reality of a human help-meet who, for his sake, cheats the milkman and jeopardises the rationing scheme. If, on the other hand, he regards women as the embodiment of evil, desire continually wars with fear If we believe that virtue is absolute, it is disheartening to find ourselves always among the goats Man has a need of virtue and a sense of right-doing, and if he is to keep going happily he must feel that some of his arrows are falling near their target, or at least travelling in the right direction

This, succinctly, is our second point the patient is struggling to fit comfortably into a niche in the external world If his picture of reality is blurred and false he will find this more difficult – perhaps impossible Here the psychiatrist can help him Any intelligent onlooker can point out the foolishness of these misconceptions (they are not called delusions because so many normal people subscribe to them), but the neurotic is shy of rational argument and the only effective approach is by demonstrating to the patient how these ideas originally arose and how they gained the power they undoubtedly possess Better still is the analytical method of leading the patient back over his life and letting him discover these early influences for himself

I mentioned three main methods of treatment. We have already created a dichotomy – our patient and his environment Our third approach therefore must embody the other two We call it adjustment, fitting the patient into the real

compartment may become so strong that he no longer dares to make the journey and he stops off work. Financial worries now add to his misery. The treatment of claustrophobia may unfortunately be long drawn out and the social worker must step in to fill this gap. She is not content with helping the patient to obtain financial aid from the appropriate authority or charitable institution. Bread and butter may be essential for the patient's existence, but self respect is just as fundamental to mental health and the social worker should find the patient similar work near his home. Alternatively, she can help him to obtain accommodation within walking distance of his original job.

Altering the patient. Many conflicts are due to reactions more relevant to the child than the adult, or they may be due to false beliefs which the patient has acquired early in life and which colour his picture of reality. To take a simple example, boys are often brought up to believe that women are different – angels in thought, noble and unsullied by the unpleasantness of life's struggle. This is known to psychiatrists as the error of the pedestal. Alternatively, the contrary delusion is equally common – that women are scheming, false and a certain ruin to the man who meddles with them. This is known, perhaps a little more cynically, as the error of reality. Both these errors are typical of the misconceptions a patient may have about reality. They are a type of fallacy inherent in human thought – generalisations from the particular and exaggeration of the importance of what we happen to have experienced ourselves. These fallacies do not easily suffer spontaneous correction, and for two main reasons. First, they are often beliefs stamped early into the mind of a child by a parent. To the child, the words of a parent or parent-surrogate have all the authority of the *ex cathedra* statement of a being who is at one and the same time the most feared and the best-loved person in the world, and whose omniscience has not yet been questioned. To deny these beliefs is to deny the parent himself, and however emancipated we may feel this arouses immense

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world Having made our assault on the environment (social therapy) and having altered our patient (individual therapy) we do not, unfortunately, find an easy fit. Bluntly, he must lump it, and we must help him This is supportive therapy We can help him to develop his assets, seize his opportunities and learn acceptable methods of gaining self-esteem and satisfaction Like a patient with heart disease, he has to be taught to live within his limitations Briefly no moon and no tears Critics of psycho analytical technique say that what is not nonsense is common sense Of course this is true and one is tempted to reply with the adage that common sense is an uncommon virtue Sense, that is to say, rational thought is a treasure that is available now and again to everyone but never continually to even the most critical Most problems in living those between persons as well as those between nations have a sensible solution but it is a matter of common sorrow that this is so rarely applied No psychiatrist is himself perfect but he is a specialist in interpersonal relations In a world where perfection is only a rumour the lame can sometimes teach the paralysed to limp

One of the limitations of psychiatry has always been the amount of time which the therapist should devote to each patient Orthodox psychiatrists may devote several hours to the investigation of one case and treatment may entail many more An analysis may require two or three hours a week for a year or longer A second limitation is that the patient's problems are often ones of social adaptation He sees his doctor in private he however takes his advice to heart and goes away to try and put it into practice How much better it would be if his doctor could see him in his trouble and try to help him adapt on the spot Both these limitations are removed to some extent by group psychotherapy This implies that a group of patients is treated together rather than individually It is not however merely several individuals receiving treatment at the same time For the patient the group is an entirely different situation

from an individual treatment session His mental orientation is altered by the need to consider the other patients

Originally, group treatment was used to expedite the after-care of patients with physical complaints The first recorded use of group therapy was the experiment of Dr J H Pratt in Boston In 1905 Dr Pratt arranged a series of meetings for a group of tubercular patients and gave them formal instruction in hygiene and careful living The original impetus for the experiment was a desire to save time but Pratt soon noticed that the patients enjoyed meeting together and gave each other mutual encouragement He was not slow to develop his discovery and soon started groups for the treatment of other chronic diseases such as raised blood pressure and diabetes So successful were his results that his methods were quickly adopted by workers in other parts of America In the field of mental illness the benefit of group activities had been noticed earlier In 1904 Dr Camus and Dr Pagniez working in the Salpetrière (Paris) published a report on their experience with the prolonged rest treatment devised by Dr Weir Mitchell They noted in passing that the patients in the large public wards were considerably more cheerful than the patients treated in private rooms These workers however did not appreciate the importance of this observation and the credit for the first conscious use of group psychotherapy must go elsewhere By 1909 Dr Marsh was experimenting in America with the group treatment of the psychoneuroses In Vienna in 1911 Dr Moreno began his famous experiments with problem children He treated these patients too young for formal analysis by methods analogous to play therapy He encouraged the children to act out their fantasies in miniature plays and thus laid the foundations of psycho-

seems obvious, and practice appears to bear this out, that group treatment offers a more natural environment for the adjustment of some emotional disturbances than does the intense focal point of individual analysis Group therapy also enables the patient to form more diffuse and less intense emotional ties while under treatment, and he is spared the necessity of switching them on and off suddenly. Friendships formed in the group may be continued into everyday life Group therapy is not a comprehensive panacea and should be part of a wider therapeutic plan First the patient should be given a lengthy diagnostic interview at which a comprehensive history of his illness and the background of his life is recorded This should be followed by a thorough physical examination to exclude or evaluate any organic disease If any doubt remains, special pathological tests will almost always settle the point Only when the patient has been thus diagnostically assessed is it possible to lay down a rational plan for treatment Group therapy may be the main treatment suitable for a particular patient, but even so it must be supplemented by individual therapy. Such individual treatment should if possible be given by the doctor who runs the group On the other hand, group therapy may be an adjuvant to the physical methods of treatment.

The conditions which benefit most from group psychotherapy are the psychoneuroses – particularly anxiety states and reactive depressions and the psychosomatic illnesses such as peptic ulcer, high blood pressure and asthma In these latter conditions worry and tension aggravate the organic lesion if they do not actually cause the physical changes As every member of the group will influence the progress of th

drama These methods soon caught on and it became clear that patients who received group therapy showed greater improvement than those treated individually They were *getting something extra* What is *the* cause of this extra benefit ?

'Psychotherapy has two main weapons – a direct appeal to the intellect and an indirect approach through the emotions The emotional situation which arises between doctor and patient is far older than the study of psychological medicine and has in fact always played a part in medical treatment In psychotherapy this emotional bond assumes a very *important role* and has been *dignified by the special* name of transference The formation and subsequent control of a positive (helpful) *transference* between the therapist and his *patient* is one of the most difficult aspects of psychotherapy A positive transference is easily acquired to start with but as treatment *progresses* and the patient is faced with unwelcome home truths and the loss of some of the *protection* he obtained from his illness he evinces *marked* hostility This is the stage of negative *transference* and unless it is handled carefully he may break off treatment Even a favourable emotional situation can sometimes interrupt treatment as effectively as it can aid it A crucial point in psychotherapy is the careful dispersal of the *therapeutic transference* when the treatment is *drawing to* a close Mistakes here will lead either to a pathological dependence on the analyst or to a sudden loss of all the ground so exhaustingly gained It is in its different approach to the transference situation that group psychotherapy makes an important advance

The basis of the emotional life is very imperfectly understood, but it is clear that normal people have a great need *to love and* be loved Part of this emotional *pool* is used up on individuals – parents siblings, spouse friend lover some of it is directed towards *groups of people* the village the office, home and country or even towards symbols or *abstract conceptions* such as the flag or democracy It

seems obvious, and practice appears to bear this out, that group treatment offers a more natural environment for the adjustment of some emotional disturbances than does the intense focal point of individual analysis. Group therapy also enables the patient to form more diffuse and less intense emotional ties while under treatment, and he is spared the necessity of switching them on and off suddenly. Friendships formed in the group may be continued into everyday life. Group therapy is not a comprehensive panacea and should be part of a wider therapeutic plan. First the patient should be given a lengthy diagnostic interview at which a comprehensive history of his illness and the background of his life is recorded. This should be followed by a thorough physical examination to exclude or evaluate any organic disease. If any doubt remains, special pathological tests will almost always settle the point. Only when the patient has been thus diagnostically assessed is it possible to lay down a rational plan for treatment. Group therapy may be the main treatment suitable for a particular patient, but even so it must be supplemented by individual therapy. Such individual treatment should if possible be given by the doctor who runs the group. On the other hand, group therapy may be an adjuvant to the physical methods of treatment.

The conditions which benefit most from group psychotherapy are the psychoneuroses – particularly anxiety states and reactive depressions – and the psychosomatic illnesses such as peptic ulcer, high blood pressure and asthma. In these latter conditions worry and tension aggravate the organic lesion if they do not actually cause the physical changes. As every member of the group will influence the progress of the others, the selection of patients suitable for a group requires considerable clinical acumen. The inclusion of one unsuitable patient may completely disrupt the group and block further progress. On the one hand, the acutely disturbed or deeply depressed patient will distract and upset those less ill. On the other, the supercilious, argumentative

intellectual will spread a highly contagious atmosphere of non cooperation It is not essential that all the patients start at the same time, and in practice it is found helpful if a new patient joins a pre-existing group old members make him welcome and explain the mysteries to him Those who have never had any psychotherapy before resent the idea that their troubles are primarily mental and are inclined to doubt the efficacy of mere talk The personal story of recovery from symptoms very similar to the new patient's own, told by one of the old members, carries more conviction than all the blandishments of the most enthusiastic psychotherapist The latter also appreciates the piecemeal arrival of his clientèle because it gives him an excuse to reiterate his fundamental concepts

The number of patients admitted to a group depends on the type of treatment The 'deeper' the therapy (i e, the more analytical) the smaller the number which can be satisfactorily treated Two or three patients treated together will automatically form a group while eight to twelve is probably the ideal number With more than twenty members the session is likely to degenerate into a lecture and while this didactic form of treatment can still be very helpful, it lacks the plasticity of a small integrated group At the first session, then, the therapist will find himself surrounded by headaches, backaches, giddiness, weak legs, indigestion, palpitations, depression tremors paralyses, pains before the eyes, pains behind the ears, pains all over and just plain nerves With examples and explanations in simple terms the therapist shows how symptoms like these can be caused by mental conflict and worry He draws everyday analogies to illustrate these mechanisms at work Fear, he reminds the group, can cause sweating trembling, nausea and diarrhoea – physical symptoms, a sudden shock – even the mere sight of blood – may cause loss of consciousness, tension and awkward postures cause muscular discomfort and pain He emphasises that rigorous medical examination has excluded any physical cause for their symptoms and

leaves them to draw their own conclusions. The therapist [illegible]

[illegible]

have become used to each other and have acquired some knowledge of psychological mechanisms they are required to write their own life stories in the light of this new knowledge. Selected passages are then read out – anonymously – and everybody is invited to comment on them. It is illuminating, but not altogether surprising, that patients will often recognise more easily in others than in themselves the psychological causes of symptoms. Making this step, of course, helps considerably towards the attainment of insight into their own troubles. Throughout group treatment the patient is seen individually at frequent intervals when the more personal points and intricacies of his own illness are discussed.

In many clinics this fundamental educative side of the treatment plays a minor rôle and most of the benefit is derived from the emotional re-adjustment obtained. Many patients have never really attempted to integrate their lives with their neighbours: social conventions have dammed back the primitive expression of their drives and they have never acquired the ability to enjoy the compensating outlets that civilisation offers. Other patients have become so preoccupied with their symptoms that they have withdrawn from social activities. The psychotherapist therefore attempts to establish a communal organisation; he encourages the patients to take up hobbies and to develop any interests they have in common. He lays emphasis on the duties of the individual to the community, encourages co-operation and friendship between patients, and by pointing out how everyone can contribute in some way to the general good, bolsters up their self-respect. He teaches them muscular relaxation, which besides having a beneficial physiological effect renders them more suggestible and paves the way for

the acceptance of encouragement and reassurance Many therapists, especially in America, conclude each treatment with exhortative passages from the poets and minor philosophers The more inspirational a therapist's technique the more closely does a group session resemble a revivalist meeting Indeed, such movements as the Oxford Group use similar methods 'Alcoholics Anonymous,' a group formed by alcoholics for the treatment of alcoholics, emphasises that a fundamental step towards the success of their treatment of the chronic drunk is a change of face equivalent to a spiritual conversion The mass cures, which in the past accompanied outbreaks of religious fervour, were spontaneous examples of the mechanisms underlying group psychotherapy Special methods such as psychodrama are extensions of the same principles The patients themselves act out their conflicts and seek solutions in imaginary situations

In assessing the results of group psychotherapy it must be remembered that it is the chronic neurotics who respond best and these patients are notoriously unresponsive to other methods of treatment, usually continuing in a state of interminable disability The modest achievements which can truthfully be attributed to group treatment are therefore a decided therapeutic advance In one follow up questionnaire 90 per cent of patients replying said that they had improved, and most of these to a considerable extent When allowance was made for those who did not reply, and for those who had defaulted from treatment, the proportion showing improvement fell to just under 50 per cent Group therapy takes deliberate advantages of man's gregarious nature, and is thus planted on a firm theoretical basis Further, it has stood the test of time It can therefore safely be added to the armamentarium of the psychiatrist, but it must be remembered that group therapy is not a specific and when further light has been thrown on the aetiology and pathology of the neuroses it may well give way to a more direct method of attack

Research Report

A. W. HASLETT

Muscle measurements

For sheer delicacy of measurement and finesse of experiment it would be difficult to beat some recent observations by Prof A. V. Hill of University College, London, on the heat changes which take place during a single twitch of a muscle. The rise in temperature which accompanies such a twitch is only about 0.0025 degrees Centigrade. This in itself would present no particular difficulty for although it represents a small enough temperature change by ordinary standards, very much smaller differences in temperature can be measured. The real difficulty was that, in order to follow a single muscular twitch through all its stages and particularly to record accurately its beginning, Prof. Hill needed to measure both the contraction of the muscle and its temperature at such speed that the state of affairs at intervals of time only two thousandths of a second apart could be distinguished. It was the combination of these two requirements of speed and sensitivity which made the measurement problem difficult.

The first stage was to translate the temperature changes to be measured into changes of electric potential. This was done by a small electric thermometer or thermopile about as thick as a red blood cell is long. Its maximum output, under the conditions of the experiment, was about four millionths of a volt. This in turn was translated into a small movement of a mirror attached to a fine wire coil suspended b

is a stan

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beam when the mirror moves is observed on a distant scale

of coral growth These are the fringing reef, the barrier reef, and the atoll or coral island By the first of these is meant the type of reef which grows directly out from the coast and at low tide can be seen to be connected with it. The barrier reef, on the other hand looks to be a separate structure from the continent or island which it separates from the ocean beyond The Great Barrier Reef of north-eastern Australia stretches for about a thousand miles, acting as a more or less continuous breakwater separating Queensland from the Coral Sea On the other hand, in the typical barrier reef island, the barrier reef is an irregular circle, with the island in the middle, and usually a break in the reef on the leeward side, and safe anchorage in the lagoon between reef and island Finally, in the atoll or coral island (in the literal sense) there is no central island, but only a broadening of the coral reef on which vegetation has become established

Darwin's suggestion was that, in the typical case, these three types of formation could be regarded as stages in a single process He supposed that the original island was volcanic, as many Pacific islands obviously are In the first stage, he thought, a fringing growth of coral would become established round the edge of the island – although, in fact, there are no known examples Then, in the second stage, the island would begin to subside and the reef would grow upwards to keep pace with the subsidence, but would now be reared above a part of the island which was submerged, giving the effect of a barrier reef Finally in the third stage, the original island *would have subsided so far as to have* totally disappeared, and only the barrier reef to which it had given rise would be still visible above the surface

The theory is attractive in its simplicity, but fails completely to explain one further fact – that the depth of nearly all atoll lagoons lies between about 120 and 240 fe[illegible]
a relatively flat sea bed at that le[illegible]
reason why [illegible] below the
subsiding [illegible]

surface Nor can the theory, by itself, account for the very large amount of debris needed to level off the gap between the sloping sides of the former volcano and the barrier reef It was therefore pointed out by the American geologist H A. Daly that during the period when the continents of Europe and North America were covered in ice sheets, the level of the oceans would have been lowered by some 300 feet During this period, any pre existing coral would have been unable to survive, and he thought that the effect of waves and storms would have been to wear away the top of the island to a roughly level platform Then, about 25 000 years ago, when the level of the oceans would have begun to rise again, from the melting ice of the continental sheets, coral would have become established round the edge of these eroded platforms, and the final result would be a barrier reef, with a central lagoon of roughly the required depth. It is against the background of these two theories, which many geologists believe can be usefully combined, with the possibility of more violent movements at intermediate stages, that the results of test borings through deep coral structures are most naturally considered

Fifty years ago, the first such boring was undertaken by the Royal Society on Funafuti atoll 500 miles north of Fiji, and since then there have been further borings on the Great Barrier Reef of Australia, in the East Indies and in the island chain south of Japan But by a substantial margin there has been none so deep as that lately carried out on Bikini atoll, nor was there the same information about the depth of the basement rock Only the preliminary results of the Bikini boring are yet available These bring out two main points The first is that the layers of the atoll foundation which are now 300-575 feet below sea level appear to have been at one time exposed above sea level This suggests that, as well as the two main processes, there must at one stage have been a quite considerable upheaval The second is that the layers from 1,790 feet down to the lower limit of 2,556 feet are lower miocene and must have been formed

therefore between 20 and 30 million years ago. This would imply an average rate of growth not more than one-thousandth of the maximum rate of a foot in ten years which is possible for coral structures In other words there would be an ample margin for interruptions and reversals of movement Consequently, if money, time and equipment, can be made available it would be a project of real interest to explore a single deep structure down to and into the basement rock beneath The suggestion is that the boring should be in the centre of the lagoon, so as to give the earliest chance of reaching the basement rock, and that, in conjunction with a sunken landing barge, the existence of a number of flat-topped platforms reaching within twelve feet of mean sea level, would make such a central boring possible.

Ladd, Tracey and Hill *Science* 1948 *107*, 51

Radar and colonial survey

Methods of mapping from the air, with radar control to fix position, which were developed during the war for use in the Far East, are now being applied on a large scale in Africa by the Colonial Survey Organisation Since April of last year upwards of 150,000 square miles have been photographed in this way This includes the whole of Swaziland, and parts of Bechuanaland, Tanganyika and the development areas of Uganda, as well as some further work in Kenya. Priority has been given to those areas scheduled for ground-nut planting, and the whole programme has been tackled with a speed and urgency which would have been impossible with conventional methods of surveying There is also the advantage that, pending the translation of air photographs into maps, the photographs themselves are immediately available for any purpose for which large numbers of copies are not required These are on a scale of 1 in 30,000 – or not quite two inches to the mile Mapping from the air photographs is limited at present to a rate of 80,000 square miles a year, so that the bottleneck is on the

mapping side rather than in the taking of the photographs on which the maps are based

The system of radar control is based on measurements of the range of the aircraft from radar beacons installed in convenient positions on the ground The main transmitter with a system of this kind, is in the aircraft, and the beacons on the ground can be thought of as so many reflectors from which radar echoes are returned to the aircraft This is the reverse of the original air warning use of radar when the transmitter was on the ground, and the echoes which were measured came from the aircraft The only difference otherwise is that instead of relying on simple reflection the radar beacons are provided with auxiliary transmitters which are triggered or set off' by the aircraft transmissions thus giving stronger reply signals The measurement which is obtained is that of the range of the aircraft from the beacon, and it is usual in survey work to fly on a series of circular courses about one of the beacons In this way if photographs are taken at regular intervals of time and successive courses are accurately spaced, it is possible to make certain that there are neither gaps nor overlapping. With the addition of a second beacon or ground station the position of the aircraft is fixed The ranges of the aircraft from both are directly displayed and arrangements are made for a photograph to be taken of the instrument panel showing these two ranges the height of the aircraft and the tilt of the aircraft at the same instant that each survey photograph is taken The earliest experiments with this method were carried out in Anglesey and later the Colonial Survey Organisation carried out further trial surveys in West Africa The present surveys in central and east Africa are believed however to be the first large scale application to practical mapping. The limit of accuracy is stated to be about 75 yards

Prof C A. Hart of University College, London who was lately appointed to the first university chair of surveying and photogrammetry, was directly concerned with the

the active area on the sun's surface They found that, at the most, the width of this area could not be more than about ten minutes of arc, or some 300,000 miles on the sun's surface Any error in their measurements would have made this an over rather than an under estimate – and as a spot measuring not quite 150,000 miles across was visible at the time, it seemed a reasonable guess that the visible sunspot and the observed 'radio spot covered roughly the same area Since then, the sun has been kept under continuous radio observation, in quiet times as well as disturbed, over a period of some ten months Records have been made on two different frequencies, 80 and 175 megacycles respectively, corresponding to wavelengths of 3 75 and 1 6 metres And it has been found that one useful indication of conditions on the sun is the proportion of energy which is put into these two frequencies Under disturbed conditions, the amount of power radiated on the higher frequency is several times greater in proportion Finally, taking this change in energy distribution as the criterion, it was noticed that there was a tendency for these abnormal periods to recur at 27 days intervals, corresponding with the sun's known period of rotation This, in itself, is not particularly surprising Sunspots themselves are liable to recur at similar intervals and for the same reason although it is unusual for even a large sunspot to make more than one or possibly two repeat appearances. What is interesting, and rather surprising, about these Cambridge measurements is that, during the whole of this ten months period there seem to have been only three

it produces on the spectator but rather in the mass of information which it provides for the formulation and checking of theories of solar activity From that point of view, the dominant impression must be that conditions on the sun are not so simple as the contributions of theoretical astrophysicists would sometimes suggest.

– and of Penguins

Another scientific film which was shown lately in London was made as part of the work of the Falkland Islands Dependencies Survey It includes a series of motion studies of Adelie Penguins which, in the hands of competent zoologists, should be a useful supplement to the extensive observation made earlier by Levick on the same species and recorded in his book *Antarctic Penguins* Many shots are included of penguins jumping from sea on to land ice, with an angle of take-off of about sixty degrees with a slide in toboggan position on the ice as the usual ending. Points which could be noted were the quickness of pick-up to an upright position and the balance shown afterwards in glissading still upright, down a steep snow bank Except

was used for straightforward travel on snow, with both feet and flippers used for propulsion it compared very favourably with the similar efforts of a Weddell seal, humping its back like a caterpillar at each forward movement So few zoologists have had the opportunity of studying the movements of penguins at first hand that it would seem well worth while making a slow motion version of this and any further film studies of the kind which may become available

Blood and its evolution

The red cells of the blood play so necessary a part in the conveyance of oxygen to all organs of the body that one

were to be found in the same individual and at the same time If both had been evolved in response to other and possibly different needs, and then found useful as oxygen-carriers, it would be an odd coincidence, but not in itself particularly unlikely, that both substances should be present in the same species Haemoglobin could have originated ... then another,

by itself was sufficient to do the job

FOX *Nature* 1947, *160* 431, 823

Meson particles

Twenty years ago, it was supposed that nature made use of only two kinds of fundamental particle as 'building bricks' for the construction of atoms, and so ultimately of the material universe These were the negatively charged electron – the atom, if you like, of electricity – and the positively charged proton, otherwise the nucleus of the hydrogen atom with a mass some 1760 times as great To these, in ... eutron, which was ... the same mass as the proton It was also discovered that positive electrons could ...

axiomatic that no particles were likely to exist of masses intermediate between those of the electron and proton. There were electrons, the lightest particles known, and there were protons and neutrons – but nothing in between

Then, in 1935, on purely theoretical grounds, the Japanese physicist Yukawa postulated the existence of an intermediate kind of particle with a mass about one hundred times that of the electron No one at the time paid much attention because the existing picture appeared reasonably

Operational research

So much has been said and written about the possible application of the methods of operational research to promote industrial production that a concrete example which has lately been instanced may be worth repeating. It is due to the Shirley Institute, the cotton industry's co-operative research establishment, and consisted in the quantitative investigation of the reasons for varying output in different mills. The method was to take each process separately, collecting figures for the amounts of cotton processed, numbers of workers, hours worked, types of plant, equipment and so on. The figures showed that for the same process and the same count of yarn, the number of man hours required per pound might vary by as much as three to one. By studying some of the apparently best and some of the apparently worst mills for any particular process a good idea was then obtained of the reasons for these differences, practice in labour deployment, package size, lay-out or whatever it might be.

Up to a point, this could be described as 'merely common

[illegible]

the yardstick, might have largely balanced out. The results, in any case, suggested that [illegible]

[illegible] obtained with the same labour force and machinery. Whether this is called 'science' or 'common sense applied systematically and through figures', the fact remains that it needed an investigation by trained scientists familiar with the industry to show how much could be done. This example was quoted by Mr Herbert Morrison who as Lord President of the Council is responsible for the Department of Scientific and Industrial Research.

Sir Edward Appleton, as Secretary of the Department, has also given lately his own abbreviated definition of opera-

rearest neighbour some 70 miles away, these settlers must rely on the 'Flying Doctor,' summoned by pedal wireless, in cases of sickness Their children are pupils of the 'School in the mail box,' Australia's celebrated system of education by correspondence for children who live in remote areas where there are no schools

Beneath the surface of the Nullarbor plains lies a far-stretching underworld of limestone caverns (plate 17), deep lakes and waterways The 500 feet deep limestone deposit is a survival from the miocene, when the plain was part of the bed of the sea From these caves, the scientific party brought back two rare carved stalactites composed of mineral gypsum instead of the usual calcite these gypsum stalactites have never before been found in Australian caves, though they were previously described in the Mammoth Caves of Kentucky and a small cave in Southern France (See plate 18)

The holiday exploring party was organised and led by Mr Russell Grimwade President of the Melbourne National Museum trustees and a leading Australian drug manufacturer It comprised a forester a zoologist, an anthropologist, an ornithologist, and seed-collector and a naturalist [illegible]

aboriginal chopping axes (plate 19), parasitic plants, metallic blue spiders which hunt metallic blue ants, and the strange plant *Kinola* which grows a foot in a century and lives for several thousand years

Whalemeat

The whale is not a fish. Like the cow, it brings forth its young as calves and nourishes them on milk Like the cow, it is a warm blooded animal with the vestiges of four legs [illegible]

[illegible]

, experiments towing anæsthetised fish suggest that in hey have much more friction, and not less, to overcome a vessel of the same size and shape – but this may be to their scaly rough surface

nyway, the assumptions probably do not completely ll the calculation. They do not give the whale's true sepower, but they do show whether this horsepower is undred times greater (or smaller) than the human They e accurate to that extent, and after all, that is what curacy is – always a relative matter, not an absolute thing ccording to the experts, the value for the whale comes out about 9 horsepower per ton of muscle, which is a figure ower than that for man, after all (four thousandths against ne hundredth) So the answer seems to be that whalemeat just like human meat, mechanically speaking, and the hale's fantastic power is the result only of its fantastic re It has really no more kick to it than a cow

Folic acid again

Since the report in an earlier issue of *Science News* of the discovery of this new water soluble vitamin which is present in the leaves of plants as well as in liver and in yeast, f [illegible] to modify the original con- [illegible] matter. [illegible] rkers got on [illegible] ted to keep young chicks on a complete[illegible] c, that is to say, which contained only known proteins, fats, carbohydrates and minerals, and all the pure known vitamins Something extra was needed in the food before the chicks would grow, something that prevented their getting anaemic Experiments about the same time with various kinds of bacteria on simple casein media containing only known constituents, showed the same kind of result Before the 'bugs' would grow a supplement had to be added In the case of *Lactobacillus casei*, this was obtained from liver and yeast extracts with *streptococcus fæcalis* it was found in

or so, for a couple of hours at a stretch This muscle is very fatty, and may contain anything from one to ten per cent of extractable oil In the past it found a use, after the extraction of this oil, as a high grade cattle food or a rich guano-type soil fertiliser, now the world food shortage has brought it on to the human dinner-table as a very valuable protein food The blue whale's liver, which weighs about a ton, is also nutritionally important, for 3 per cent of it is oil rich in vitamin A

But whalemeat, in its living state, is interesting from quite another point of view The performance of the animal is so striking, both in speed and endurance of swimming, and in sheer strength, that one naturally wonders whether its muscles can possibly be the same in structure and function as those of the human body Surely they must be much more efficient machines than those in our arms and legs Otherwise, how could a whale tow a small steamer forward at seven miles an hour when its engines are racing full astern?

One way to compare the efficiency of machines is to compare the horsepower generated for a given weight of engine Now human horsepower has already been worked out, and it seems that an athlete, like the dog, generates about a hundredth of a horsepower for each pound of muscle he has in his body To get this result was relatively easy, because a man can be made to work away, for instance at pedalling a stationary bicycle, under laboratory conditions which permit of precise measurements The whale is a more difficult case, and one or two assumptions have to be made, for instance that when towing the steamer it is doing as much work as would a submarine of the same shape and displacement In other words, it is like a rigid steel body forging through the water, with a similar water skin friction resisting its passage It may be, however, that the whale, being flexible and not rigid, and oiled all over, has less water resistance to overcome, and wastes less energy in producing wake eddies than the st[illegible]

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As in a great deal of modern vitamin research, workers got on the track of an unknown when they attempted to keep young chicks on a completely synthetic diet, one that is to say which contained only known proteins, fats, carbohydrates and minerals, and all the pure known vitamins Something extra was needed in the food before the chicks would grow, something that prevented their getting anaemic Experiments about the same time with various kinds of bacteria on simple casein media containing only known constituents showed the same kind of result. Before the 'bugs' would grow a supplement had to be added In the case of *Lactobacillus casei* this was obtained from liver and yeast extracts with *streptococcus faecalis* it was found in

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may be three, i e , two more attached at the asterisk, or even seven, as though the mechanism which makes the [illegible] and [illegible] hese [illegible] the form with seven glutamic residues, for instance, is effective in the diet for chicks, but useless in the bacterial test There exists an enzyme in animal tissues which breaks down the more complex forms to simple folic acid

It was natural, in view of the effect of folic acid deficiency on the blood of chickens and monkeys, to try the effect of it on various human blood diseases In this way it was discovered accidentally that folic acid would 'cure' pernicious anaemia That is to say the anaemia would clear up and the blood remain normal as long as the correct dose of folic acid tablets was being taken The quantity required was quite large – 5 or 10 milligrammes per day At first it was thought that this would become the modern treatment, replacing the nuisance and expense of crude liver injections But one aspect of the disease had been overlooked

Pernicious anaemia itself is an illness in which there is a failure to produce the red cells of the blood, only a few are made and they are abnormally large Associated irregularly with this (the causal connection is obscure) there are nervous symptoms grouped under the heading of subacute combined degeneration of the spinal cord The nervous symptoms may be marked and the anaemia slight or the anaemia alone may be present followed only after some time by the nervous degeneration which has nothing to do with the severity of the anaemia It was early found that folic acid unlike liver would not affect the nervous side of the illness, but it took about two years of experience to show that people with anaemia only and this anaemia successfully treated with folic acid might develop subacute combined degeneration nevertheless In other words folic acid was dangerous because it lulled doctor and patient into a false sense of security It affected the blood, but not

the nerves, and was only a half-cure The truly curative substance present in liver extracts is still (March, 1948) a mystery: it is not folic acid, but it may be a chemical relative *

In another illness, however, folic acid appears to be having a marked success Tropical sprue is a disease with great diarrhœa, and an anæmia somewhat like the pernicious type In a matter of days from the start of treatment, folic acid often arrests the diarrhœa, the health of the intestines improves, and the anæmia lessens. So far no fly in the ointment has been announced.

* Very recently Dr E Lester Smith of Glaxo Laboratories, Middlesex has announced the isolation from liver of a red pigment which is [illegible]

[illegible]

American workers, and further news of them, will appear in a later issue of *Science News*

Minor Additions in Metals and Alloys

DR F. A. FOX

It is to-day becoming increasingly understood that our present level of engineering technology is in large part due to our skill in manipulating alloys. However, although it is well known that, where mechanical strength is needed, pure metals are too weak to do what modern engineering requires, it is not so widely understood that the amount of the critical alloying addition is often remarkably small. Most non specialists have the haziest idea of how alloys are constituted and tend to think of additions of tens per cent being necessary before metal B will have much effect on metal A. Some of the best known and oldest alloys do contain large amounts of the added metal, as for example zinc in copper to make brass, and copper in gold to make the usual jewellery alloys. As, however, the science of metallurgy has developed it has become possible to do two things – first to begin to isolate the causes of differences in behaviour of apparently similar alloys, many of which sometimes refused with a subtlety which seemed almost perversity to do what was expected [illegible] by inductive [illegible] to formulate [illegible] combin[illegible]

[illegible] some of the fundamental guiding prin-

the nerves, and was only a half cure. The truly curative substance present in liver extracts is still (March, 1948) a mystery: it is not folic acid, but it may be a chemical relative.*

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* Very recently Dr E. Lester Smith of Glaxo Laboratories, Middlesex, *has announced the isolation from liver of a red pigment which is* powerful in treating pernicious anaemia, though it does not contain folic acid. Simultaneously, workers at Merck Laboratories, New York, have isolated a crystalline 'vitamin B_{12}', which is also powerful in treatment. The relation between the discoveries of the British and American workers, and further news of them, will appear in a later issue of *Science News*.

The effective particles of alumina have not been positively identified even at the highest magnifications under the microscope, yet they affect the behaviour of the steel in which they occur in a radical way The effect of gases on the behaviour of metals and alloys is often complex, generally they are harmful, but the addition of oxygen to

in manufacturing processes Another example is provided by the use of carbon monoxide to improve the hardness of mild steel on the surface ('case-hardening'), the gas reacts with the iron, and iron carbide, the hardening constituent, is formed in the outer layers of the part which is to be hardened

From the scientific point of view the interest is naturally focused on the picture which can be formed of the operative changes occurring within the structure of the metal.

Structure of metallic crystals.

It was long ago shown that metals are crystalline and that the ordinary alloys of industry are composed of a mass of crystals or 'grains,' which are clearly to be seen under the microscope if the piece is polished and suitably etched It is also well known that the grains of a piece of metal, even though they do not advertise their crystalline symmetry by showing geometrically formed faces, have a beautiful internal regularity which can be revealed by X-ray

peats indefinitely in all directions and is bounded only by the limits of the piece itself or, more usually, by the boundaries of the individual grain The neighbouring grain has, of course, the same structure, but it is differently

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. . . . been done in recent years

10^{-7} to 10^{-8} cm and the lattice forces large The periodicity of properties shown in the table of the elements was an early pointer that atoms could not properly be considered as minute billiard balls, and that structures within the atom itself were critical Metals are characteristically electropositive This fact involves the implication that their atoms may be readily separated from one or more of the electrons which these contain From the study of the forces in the space lattices of metals, the general picture has fairly recently emerged that the lattice points are occupied not by atoms, but by positive ions from which one or more electrons have been separated the electrons are more or less free to move in the interstices of this structure, forming what may be described as an electron gas", the electron gas or cloud is the decisive agency in holding the structure together, the ions themselves having a mutually repulsive effect. This picture is one for the most electropositive metals, other types of lattice bonding apply for those which are less characteristically 'metallic' – for example the structures of arsenic, antimony, bismuth, selenium and tellurium are bound together by forces which are more like chemical linkages

Mechanisms of alloying

When an alloying addition is made to a metallic element, the question at once arises – how can the atoms of the alloying element be accommodated in the structure of the parent metal? Great numbers of investigations have been made over many years to follow the changes that occur when alloys are made, years ago the microscope and the cooling curve were the principal research tools and a great body of knowledge was built up with their aid. More recently X ray and other techniques of modern physics have been adding to the data and are being also used to help formulate theories as to the

oriented in space and the grain boundary is a zone in which the atomic arrangement is locally not perfectly regular since *it is one of transition from one orientation to another*

The geometry of the crystal structure or 'space lattice' is characteristic for each metal although three common types

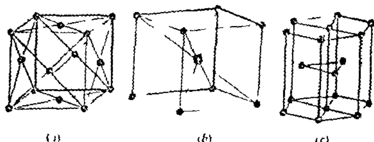


Fig 25 (a) Face-centred cubic structure unit cell (b) Body centred cubic structure unit cell (c) Close packed hexagonal structure unit cell

of symmetry are recognised Two of these are included in the cubic system in which the unit of atomic brickwork of which the structure is built is cubic in form The two common types of cubic unit cell are the face centred cube and the body-centred cube *In the former the unit cell is a* cube with an atom at each corner and one in the centre of each face, in the latter a cube with one other atom right in the centre of the cube itself (at the intersection of diagonals joining opposite corners) The third common type of unit cell is that termed close packed hexagonal in which the unit is a hexagonal prism with an atom in the centre of each end hexagonal face and three others in *symmetrical positions on the central plane parallel to the* end faces (Fig 25) Most engineering materials conform to one of these three types of structure but the actual dimensions of the unit cell are characteristic of the particular metal (or alloy) minor deviations from these types also occur (for example some hexagonal metals are not close packed *in structure* but are elongated or compressed axially from the geometrical ideal)

it does so, comes out of the solution as iron carbide, Fe,C, reposes within the iron lattice, when dissolved, at points equidistant from three neighbouring iron atoms

The effect of foreign atoms in the parent lattice is naturally to cause a greater or lesser distortion of its regularity in the neighbourhood of each intruder The distortion varies with the nature of the added atoms, and with their numbers, when sufficient foreign atoms have been added to make the solid solution just unstable, then a new phase is formed if further additions are made, and this phase is of such a struct

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stabl

solubility limit one may say for example that at room temperature aluminium can hold up to 0 2 per cent of

... they may occur within the grains of the parent metal or in the grain boundary they may be in massive or in film like forms and their mechanical state of aggregation may have an influence as great as or greater than their 'inherent' effect associated with composition In no field of metallic structures is this better exempl

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conti

Age hardening

Age hardening is the name given to the spontaneous hardening of an alloy on standing after heat treatment, the metal hardens with the passage of time, like its makers' arteries This effect so well known in the duralumin type of alloy, is basically due to the fact that in the alloys showing it there is a solid solubility limit which increases as the temperature

the solution and ageing treatment is of the same chemical composition but the second phase, when in massive form (massive at least on a microscopic scale) has a relatively small strengthening effect on the structure The highly dispersed incipient precipitate exercises its great hardening [illegible]

atomic planes by which a metal deforms under load The details of the lattice distortion mechanisms vary from alloy to alloy according to the nature of the component metals

Effects of minor additions

The technical interest of minor additions to metals and alloys lies in four main fields first the addition may have some peculiarity which makes it so potent, that although minor in quantity it constitutes the main alloying effect of the system second, it may be added to neutralise the harmful effect of some impurity which it is not practicable or economic to eliminate third it may be added to counteract some undesirable behaviour of an otherwise useful alloying addition already present or finally it may be added to modify some specific physical or chemical property of the metal to a maximum (or a minimum) extent These effects the minor addition must achieve by going into solid solution in phases already present, or by causing a separate phase to appear

Light alloy examples

A good example in the first field is provided by the recently investigated alloys of magnesium and zirconium, some of which are now being developed for industrial application Pure magnesium is not used for engineering purposes since, unalloyed it is too weak One of the reasons for this weakness appears to be connected with the fact that it solidifies with a large grain size it is not only a general fact of observation that metals and alloys tend to be weak if their grain structure is coarse, but it is found that magnesium alloys as

is raised. At 518° C for example, metal A may be able to take 5.7 per cent of metal B into solid solution, but at room temperature it may hold only 0.2 per cent in solution and above this limit some separate phase – say the β phase – tends to come out of solution. Suppose now an alloy of 5.7 per cent B in A is heated to 548° C and held at that temperature for long enough for all the β phase to dissolve and to produce a homogeneous solid solution. If the alloy is then quenched in water the piece may cool so rapidly that there is no time for the β phase to come out of solution as it would otherwise do. The condition is then that of an alloy containing 5.7 per cent, and not 0.2 per cent, of B in solution at room temperature; the extra 5.5 per cent of B is said to be held in 'forced' solid solution. As a result the alloy is unstable and spontaneous changes begin to take place in the direction of precipitation; these changes cannot occur very readily since at room temperatures what may be called atomic mobility is not great, and not only is the time scale of precipitation slowed down but the state of aggregation of the embryonic precipitate is different from that associated with stability.

There has been much research, which is still continuing, on the nature of the incipient and rudimentary precipitates which form under these conditions in different alloy systems. For example in the aluminium-copper system for which the above figures apply (this is the basis of the duralumin type of alloy) the changes taking place are complex and are on a scale well beyond the ordinary light microscope to resolve, although the normal precipitate in the un-heat-treated cast alloy is readily visible under the microscope. The effect of the elementary type of precipitation occurring under age hardening conditions is observed in many alloying systems; it is to cause a distinct, and sometimes a technically decisive, hardening and strengthening of the alloy, and electrical and other physical properties are also affected. These changes are wholly due to the special state of aggregation of the alloying addition, the alloy before

The alloys of aluminium have been the subject of intensive research for very many years, and strong grain refinement has been observed to follow from minor additions of titanium, columbium and boron, but in this field the minor addition which might be classed as having the effect of a major alloying element is sodium, when added to the aluminium-silicon alloys. The normal alloy containing 11 per cent to 13 per cent silicon is distinctly weak and brittle under impact if it is cast in a sand mould to make a piece of any size. If however, 0.05 per cent of sodium is added to the molten alloy just before pouring, the metallographic structure is greatly refined and the mechanical properties of the casting are so much improved that the treated (or 'modified') [illegible]

finished casting. There are many interesting points about 'modification', chief among which is the fact that the alloy shows a modified structure even in the absence of sodium if it is quickly cooled, in other words, a thin sectioned piece cast into a metal mould would not require the addition of sodium to produce a modified micro-structure and good [illegible]

that the super saturated hypo solution in the schoolboy experiment remains liquid – because of absence of inocu- [illegible]

Counteractant additions

An example of researches in the second field is provided

phosphorus required (0·1 per cent to neutralise 0·01 per cent of bismuth) would itself interfere with the hot-working behaviour. Another line of research has been pursued in this country and a solution has been forthcoming which is effective for high as well as room temperatures. The attack was to test the effect of alloying additions which form stable compounds with bismuth; among these was lithium, which forms the compound $BiLi_3$, with a melting point of 1145° C. It was found that an addition of 0·0[illegible] per cent lithium entirely eliminated the harmful effects of bismuth up to 0·01 per cent. The formation of the high melting point compound would naturally lead to the elimination of the liquid phase so harmful to the cohesion at high temperatures. The addition of lithium is also effective in preventing the bismuth embrittlement of copper-tin and copper-zinc alloys.

Another example of the 'set a thief to catch a thief' technique occurred in zinc alloy research work. Some years back a serious trouble with zinc alloy die-castings was that they were found to weaken spontaneously with time; they became brittle and even sometimes disintegrated after a few months service. It was found that the trouble was due to [illegible]

thus prone to atmospheric corrosion spreading along them, which caused weakening and disruption of the metal. The amount of tin which could have this unwelcome effect was particularly small – of the order of 0·002 per cent. As lead and cadmium were present in the crude metal, the problem of dealing with them was in the last resort a matter for experts in extraction of the zinc; in the meantime a temporary solution was found, however, by the addition of magnesium to the casting alloys. It was found that about 0·1 per cent of magnesium would make the alloys fairly stable to tropical atmospheric conditions provided the concentration of lead, tin and cadmium were not too high (0·005 per cent for cadmium and tin, and 0·010 per cent for

by the harmful effect of small amounts of bismuth as an impurity in copper. If copper contains more than about 0.005 per cent of bismuth its ability to be hot-rolled falls very seriously, and as hot rolling is the standard way of making copper sheet, this influence is economically most undesirable. Copper refined by an electrolytic process contains negligible quantities of bismuth, but it is always present in copper which has not been treated in this way, and no other satisfactory way of removing small quantities of bismuth is available. The amount of bismuth entering solid solution in copper is less than 0.002 per cent; any bismuth occurring above this limit in pure copper does so as metallic bismuth itself. Its strikingly harmful effect is exerted because its presence gives rise to small quantities of liquid metal when the copper is heated for hot rolling; the liquid spoils the continuity of the metal and causes cracking; it also adversely affects cold rolling because the bismuth, which is weak, tends to take up film-like forms between the crystals of copper, destroying their cohesion. If the copper contains oxygen, as it often does, then the bismuth occurs as the less harmful oxide, Bi_2O_3; above 800° C, however, metallic bismuth is formed. The approach to the problem has had to be along the lines of finding some addition agent which will neutralise the harmful effect of the bismuth by combining with it to convert it into some relatively harmless form or compound.

Australian research showed that one agent which could be used to eliminate, at least at room temperature, the brittleness of bismuth-contaminated copper, was phosphorus. The use of this element is an easy matter for the copper refineries since copper is often deoxidised with phosphorus, and all that is required is to ensure that there is enough phosphorus left in the metal to neutralise the bismuth. It seemed probable that the phosphorus worked without combining with the bismuth, but by causing it to assume a globular, non-film-like form, perhaps by some surface tension mechanism. This answer was not perfect, however, since the amount of

phosphorus required (0 1 per cent to neutralise 0 011 per cent of bismuth) would itself interfere with the hot working behaviour Another line of research has been pursued in this country and a solution has been forthcoming which is effective for high as well as room temperatures The attack

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and comes from the interior of the crystals to reach the grain boundaries, at which precipitation occurs, the chromium [illegible] far [illegible] the [illegible] the crystals, near the grain boundaries Since these outer layers must contribute enough chromium to supply 15 to 18 times the amount of carbon coming from the whole of the bulk of the crystals, they suffer a severe loss of chromium and as a result the corrosion resistance of the metal is locally destroyed. Stainless steel which is in this condition, if subjected to corrosive conditions, suffers rapid attack at the grain boundaries, and in time may disintegrate This effect was originally noticed in stainless steels which had been welded, and it was termed 'weld decay' in the shops, 'intergranular corrosion' in the laboratories

Thus bad effect of an otherwise useful alloying element, could be countered by three methods by reducing the carbon content so that precipitation does not occur, by introducing some other element which has a greater affinity for carbon than has chromium, or by suitable heat treatments The first is not practicable from a manufacturing viewpoint, and the last is often not economic or convenient, especially for welded pieces The search for the antidote element was, however successful, and three answers were found. The most commonly used alloying addition to prevent intergranular corrosion of stainless steel is titanium which has the required high affinity for carbon and forms a [illegible]

becomes immune from weld decay In welding however, the presence of titanium in the welding rod does not necessarily produce weld metal which is immune from intergranular corrosion since a large part of the titanium may be oxidised during the welding and the loss will be critical if several

crossing or overlapping welds have to be made In these circumstances the *alternative solutions may provide better* results – 0.75 per cent of columbium or 2 per cent silicon – since these elements do not suffer such loss in the welding operation, and consequently can more readily ensure that the chromium is kept in its proper 'defensive' place in solid solution

Restriction of grain growth.

Examples of the use of minor additions to modify specific *physical or chemical properties of metals and alloys are* numerous Interesting illustrations lie in a field allied to that of grain refinement touched upon earlier, this is the *restriction of grain growth It is a general rule that* metals which have been mechanically worked (rolled, forged, etc.) may tend to undergo grain growth when they are heated, i e, certain grains grow by *swallowing their neighbours* It often turns out that severe grain growth is undesirable since it is accompanied by loss of strength and hardness If it is an unavoidable part of some operation that a metal or alloy has to be submitted to a high temperature, then it becomes desirable to try to restrict the resultant grain growth in some way, to avoid its weakening effects A familiar example of metal exposed to very high temperature is that of the tungsten filament wire in ordinary electric lamps which runs at temperatures well over 2 000 C If tungsten without any additions is used for filament wire the grains become enormous as the lamp's life continues, as a result the metal becomes brittle and the grain growth causes distortion or sagging under the filament's own weight An addition is therefore made to the tungsten during the manufacture of the wire, of an agent capable of obstructing the growth of the grains, 0 75 per cent of thorium oxide (thoria) is very *effective* in this way, being insoluble in the tungsten, and when finely distributed throughout the structure the particles present a durable mechanical obstruction to grain growth Tungsten containing 0 75 per cent thoria thus

permits the production of filament wire with a much increased service life

Before a worked metal undergoes grain growth when it is heated, it usually recrystallises – that is, among the crystals which were distorted by the working process, appear tiny new ones, which are not distorted, these begin to grow as the temperature is raised further, and they finally obliterate the old structure The metal is then said to be 'completely recrystallised' Most metals are much strengthened by being worked, and recrystallisation causes the increased strength to be lost with the obliteration of the old crystals Pure copper is rather weak, but is valuable for its high electrical and heat conductivity; for some uses in which strength is needed as well as good conductivity, it is used in the worked state, such for example as hard cold rolled sheet, suppose, however, that this copper has to be soldered, the heat of the soldering operation will perhaps be enough to cause recrystallisation and loss of the desired extra strength put in by the working Here the problem is to find an alloying addition which will raise the recrystallisation temperature, thereby avoiding the softening, but which will not interfere with the good conductivity of the metal Copper is most sensitive to minute traces of impurities, many of which cause a great drop in conductivity, the selection of permissible alloying additions is, therefore

properties in copper, it also has no bad effect on the strength of the worked copper, but 'postpones' to much higher temperatures the softening effects of heating for operations like soldering This small addition of silver thus permits the use of copper when strength and high conductivity are required, and when a high temperature is to be met during manufacture

This short and rather simplified review will perhaps help

to bring home to non-specialists the idea that the metal laboratories are to-day very much concerned with 'minor-addition-metallurgy'.

[Beginners in this field may find it helpful to read first the article *Metals* by Sir Laurence Bragg which appeared in *Science News* 1 —Ed.]

GLOSSARY

BIRTH RATE This is calculated as

the number of babies born during one year / 1000

[illegible]

DEATH RATE The crude death rate for a population is

the number of deaths registered in the year × 1000

the total number of people alive half way through

Here the word population denotes a group living within definite geographical boundaries Consequently, to get the correct number of deaths, allowance must be made for residents who die while away from home and the deaths of visitors from abroad must be discounted

Specific death rates in general are calculated in the same way but refer only to one group of the population, e g teen-agers bus conductors women comparing the number of their deaths with the number of them all alive

FERTILITY An estimate of the extent to which people can and do multiply Thus the Birth Rate (*see above*) is an attempt to measure it but one liable to mislead since no account is taken of the number of women in the population of the right age to have children

[illegible]

arrange the future If you are already ninety when you read this

you know that the time is not long – much shorter than if you are only ten. A life table shows the probable expectation of life of a person at any age calculated continually from the observed ages at which people die. Owing to the progress of public health measures and of medicine and surgery, and perhaps for other unknown causes, the ages at which most people die continually alter (people on the average live longer now than they used to a hundred years ago), so that the life table must be always brought up to date.

MAGNETIC SUSCEPTIBILITY. A coefficient which indicates how easy it is to magnetise a given substance. Every schoolboy knows that iron is easily made into a magnet (i.e. has a high susceptibility) whereas aluminium, for instance, cannot be so treated and therefore has a very low value.

About Our Contributors

A. E. Bell, Head of the Science Department, Clifton College, is a chemist who has become equally interested in the history of Science. His book on *Christian Huygens* appeared earlier in the year, and his chief interest is in the educational problem arising through the need for scientists of wide culture in modern civilisation.

I. W. Cornwall was born in India in 1909. He is a graduate of Cambridge and holds the Academic Diploma in Prehistoric Archæology of the University of London, where he occupies the post of Secretary at the Institute of Archæology. His chief interests are in human evolution, the skeletal remains of early men and sub-men, and the study of their environment and equipment as shown by Geology, Palæontology and Archæology.

J. L. Crammer has been editor of *Science News* from the first issue originally under a pseudonym. He has had experience of Service life and of journalism, is a Science graduate of Cambridge, where he has done research, is medically qualified and has practised medicine. He is now twenty-seven.

Frank Dickinson is a contact lens practitioner who has written several technical and general articles on the work which he has been doing for the past ten years. He has lectured extensively abroad and at training centres and technical colleges here, and is a member of the Council of the Contact Lens Society.

Francis Fox graduated in Metallurgy at Birmingham, and took his first job on a gold mine in West Africa. He has been engaged in metallurgical research ever since he returned to this country and is best known for his publications on magnesium alloys for which he was awarded his D.Sc. He is at present Deputy Director of the British Welding Research Association.

A. W. Haslett is a Cambridge graduate who has made scientific journalism his career. He is Editor of *Science Today* and for some months past has been a regular speaker in the B.B.C. Forces Educational Programme.

Robert René Kuczynski, who died at the end of last year, was one of the greatest demographers of our time. The University of London appointed him in 1939 to the first Readership in Demography [illegible] 1944 he was appointed demographic [illegible] *Balance of* [illegible] 1932).

GENETICS

BY H KALMUS

Though genetics is the youngest of the biological sciences it is exciting more attention among both scientists and layfolk at the present time than any other branch of biological inquiry

It has grown so fast, and in so spectacular a manner that the majority of scientists and even of biologists cannot keep abreast of it in consequence it has won an undeserved reputation for being difficult to understand How undeserved will be apparent to every reader of this book for Dr Kalmus and his collaborator Miss L. Crump in comparatively small space here set out in simple language the main principles of this science so clearly and concisely that every reader however previously ignorant of its axioms and achievements will be able to follow

Part of the supposed difficulty perhaps resides in the special terminology which genetics has created to meet its special needs But no one need be deterred from making a

[illegible]

for th readers of their pages

What factors of biological make-up are inherited in plants animals and man how they are inherited how mutations and variations arise and are transmitted the importance of genetical knowledge to the gardener farmer stock breeder and human parent all these matters are discussed and explained and the text is elucidated by a number of simple diagrams

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